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PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,
Business Manager.

140 NASSAU STREET, NEW YORK

R. V. WRIGHT, E. A. AVERILL, } Editors.

APRIL, 1908

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STEEL PASSENGER EQUIPMENT.*

By Charles E. Barba and Marvin Singer.

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THE CENTER SILLS AS A COLUMN.

Referring to the previous article.—In the last sub-heading the center sills were briefly dwelt upon in their capacity to act as a column to resist service shocks due to buffing. Therein was noted the fact that to solve the problem, considering the column as one with free ends and a length equal to the total length of the sills over the platforms, was foreign to the design and would introduce fictitious stresses running far above the ultimate strength of structural steel as given in the manufacturers' specifications. The conclusion, based upon this fact, was drawn that the design should be so worked out that short portions of the beams included between the transverse supports would partake of the nature of short compression pieces with fixed ends. The ends being fixed by the construction in the locality of such support would reduce the normal deflection, and hence the bending moment and stress at the center of each sub-span.

Rankine's formula:

$$S = \frac{P}{A}\left[1 + \theta\,\frac{l^2}{r^2}\right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ 1$$

was specified as being the best to apply to this case where

P = end shock (static).
A = sectional area.
l = span length in inches.
r = radius of gyration.
θ = constant depending upon the material and end construction, tables for which are given in Merriman's "Mechanics of Materials."

This formula shows that

$$S_1 = \frac{P}{A}$$

is a direct stress due to the buffing force being equally distributed over the area and that accompanying it is a stress

$$S_2 = \frac{P}{A}\,\theta\,\frac{l^2}{r^2}$$

due to the struts deflecting throughout the span and introducing flexural strains which reach the above value at the middle ordinate of the span. The proposition was advanced that this latter stress should be used as a measure of a uniform load which would produce a bending action of approximately the same amount throughout the beam. This uniform loading was noted to be considered as acting at right angles to the uniform loading imposed upon the same beams by the central floor and capacity loading. Quoting the final sentence: "This condition holds when the transverse supports are firm in a combination of either tension or compression and flexural stresses and the center sills have their greatest least radius of gyration about a vertical axis, as is true in this case."

To make this condition strictly true there should be added to the above necessities, that the connections at the platform ends should be such that any load, coming upon the buffers or end casting, would be taken concentrically by the center sill beams. This is a feature which must not be overlooked under penalty of having destructive secondary stresses brought into action by the bending moment due to the eccentric action of the end shock about the vertical neutral axis of these beams.

The preliminary study for necessary sections may be hasty and many refinements may be avoided, but a final investigation should be made of each design using net areas and whatever expedients are necessary to secure a just appreciation of what the frame will measure up to when put to the test.

Though this article pays most attention to the idea that the center sills as struts will deflect in a horizontal transverse plane, there is a possibility that the car may so alter the conditions that it will be the vertical longitudinal plane instead. The final investigation then should cover the latter assumption and the fitness of the calculated beams should be examined as if the end shock was acting about the horizontal neutral axis of these sills and as a consequence with a tendency to augment the bending due to the vertical lading. This is a natural consequence of concentric end loads acting upon a side loaded girder—that they tend to increase the present deflection. The conditions surrounding this type of underframe design are peculiar, in that the sills are so much weaker in the horizontal plane than the vertical that when the supports are spaced close enough to fulfil the short strut conditions demanded of the center sills they will still be found to be weaker in this plane even after the effect of the lading in the vertical plane has been imposed. There are certain constructive features, such as weights of lading, size of beams and disposition of transverse supports, which introduce disturbing elements and no hard and fast rule can be laid down concerning the line of weakness. Both planes must accordingly be solved.

Eccentric End Loads.—The fact that the end load hardly ever impinges concentric with the vertical, due to the end design, will not be dealt with at any length here, as this same question of eccentric loading has been discussed in a previous section (January, 1908, p. 13). In that case the load was eccentric in the horizontal plane, but the principle remains the same, except that in this case the forces and leverages are at quadrature to what they were in that one. This principle involves the addition of the eccentricity of load application to the maximum deflection of each span for total leverage of the end load to secure the maximum bending moment. In this case the general equation of the arm would be the same

$$e + \int_{x=0}^{x=\frac{1}{2}} Y\,dx$$

where e represents this eccentricity in inches and Y represents the equation of the elastic curve. This equation must here be made

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to suit the conditions of a continuous column of which each span is similar to a strut with fixed ends. Having secured the deflection from the integration of the curve, the procedure is similar to what follows after the deflection for the concentric loading has been determined.

Concentric Loading.—If formula (1) be transposed into the form

$$P = \frac{SA}{1 + \theta \frac{l^2}{r^2}}$$

it is evident that the maximum end load, which the center sill column is capable of sustaining without exceeding a specified fiber stress, is decreased from the load, which a simple compression piece will sustain, by just such an amount as the quotient obtained from dividing the product of the stress into the area (SA) by $1 + \theta \frac{l^2}{r^2}$ is decreased by increasing unity by $\theta \frac{l^2}{r^2}$. Unity in the denominator thus denotes the divisor which obtains for the simple compressive stress uniformly distributed over the sectional area and $\theta \frac{l^2}{r^2}$ represents the reduction factor introducing the effects of flexural bending. With a given material and end arrangement, the slenderness ratio $\frac{l}{r}$ governs the destructive action of these concentric end loads, apart from the direct compressive stresses. To increase the value of the static equivalent of the permissible end shock, or inversely to decrease the stress occasioned by any assumed maximum load, it is therefore advisable to design the strut with this quantity as fractional as conconstructive limitations will permit. Decreasing the value of l or increasing the radius of gyration in the plane of distortion will accomplish the result sought. This of course assumes that these quantities are varied without the change in design affecting the value of θ. The value of l is generally determined from conditions obtaining in the superstructure. The arrangement of windows desired, limits the post spacing for the sides. These posts are the vertical stiffeners for the load sustaining girder and the transverse supports should impose their load upon the side sills in the region of the vertical posts, if the minimum stresses are to be had in the web and top and bottom members of the vertical girder. The limitations governing the available variation in l are apparent from the above considerations of minimum stress. The value of r, however, submits to the easiest variation for the securing for any appreciable reduction of stress. This should be as large as weight limitations will allow.

It is not necessary that structural shapes be used for the sills, nor is it required that the shapes be used as found in the cars now running designed after this form of framing. It is customary to construct these underframes with the center girder composed of two separate sills of commercial I or channel section. No cover plates are used and the only effective bond existing between the structural girders or columns is at the regions of transverse supports and this is at fault when but the bottom flanges are fastened to these supports. The resistance offered to bending in a horizontal transverse plane is quite low in this character of design, as the radius of gyration can be considered but double that calculated for a single shape. Latticing the two sills is of doubtful value as regards the effects of this bending. Cover plates are the only efficacious method to take up these bending moments. The fact that the radius of gyration is independent of the spread of the separate sills simply makes the problem one of dividing the total shock evenly between the two columns and designing each beam for its proportion of the load. The bad feature is the great proportionate difference in values of r for the two perpendicular axes. There should be a preponderance in the vertical plane, as the static loading is ever imposed in this direction. An investigation of tables showing varying weights of standard sections produces the conclusion that the I section offers the best advantage for use in this connection, but even here the preponderance is too large, for instance, the heaviest 6-inch I section gives a ratio of radii of gyration as 1 is to 3.4 for the horizontal to vertical planes.

In studying what effects the disposition of the separate beams, with respect to the longitudinal center line of the car, would have upon their resisting qualities we have arrived at conclusions at variance with the opinion of some car designers, but unfortunately have not had oportunity to develop them into an actual construction to note their value. It has been stated that the placing of the sills with respect to one another, that is, the distance apart will not affect their value as resisting bodies for any end shock coming upon them. Looked at in the light of a column this conclusion seems true, for the direct stress is $\frac{P}{A}$ and the flexural, $\theta \frac{P}{A} \frac{l^2}{r^2}$, as noted before. This result changes when the expedient used later on is adopted and the bending is assumed to have been occasioned by a side load producing the same deflection. This expedient rests on a sound theoretical basis. In this case the center sills become central resisting bodies of a bottom girder or truss, and the more remote or the nearer they are to the center line of the car, just in such degree is their effect upon the resistance to this imposed side load changed. This is clearly seen in the first term of the moment formula for the plate girder solved later on. This whole analysis rests upon the basis that the center sills must bend together and in the same direction which they must do to avail themselves of the efficiency of the deep floor girder for strength in this plane. Additional ties should therefore be spaced between the two beams at points between the transverse supports. The manner of load transference through the trussed and plate floor girder is discussed separately under each type of girder. There is a construction, however, which this same question of spacing of sills and the probability of wider spacing tending to the imposition of eccentric end shocks, has brought to our attention. That is, the possible method of making the center sills independently and separately assume their share of the load and in bending so construct them that their tendencies toward bending and deflection oppose each other and neutralize. Thus there would be no load in the transverse horizontal plane to come upon the floor girder and the side sill angle could not be loaded with this twisting force upon it. The transverse supports could here be designed but for vertical load carrying.

This idea would require additional weight in the center of the car, but just how much we are not prepared to state, as the idea has not been developed by us to reach any definite result. From what has been done we feel safe in predicting that it will show economies, and if so we shall present at a later date the lightest design of this type of underframe which can be built to stand up under the service. If this idea has been used in the design of any cars thus far built it has not come to our notice, and the following mathematics and presentation will be made to cover designs which have been built or are now being worked out.

The concentric column load deflects the sills and produces a bending moment which is theoretically indeterminate from any column formula. This follows from the fact that in developing the relation between stress and imposed load by means of the elastic curve of such bending, the deflection is found on both sides of the general equation after the integration has been twice performed and hence the deflection cancels out and the arm of action of the imposed end load cannot be determined. This moment would be $P\triangle$ where $\triangle$ is the indeterminate deflection.

However, the stress occasioned by this moment is given and found to be

$$S = \frac{P}{A} \theta \frac{l^2}{r^2}$$

This can be used as a measure of a uniformly distributed side load producing the same stress.

From the construction necessary to make the sills sustain the assumed end shock—that the connection at the cross bearers must

be rigid so that the sections of the sills between transverses may be solved as short struts—it is evident that the strut is in the condition of fixed ends and that the side load distributed over the sills would in reality make of them a continuous beam in the horizontal plane.

The equation of the stress $S = \frac{P}{A} \theta \frac{l^2}{r^2}$ to the stress $Mx \frac{c}{I}$ according to this assumption, where Mx is the moment at the center of the span of a continuous beam uniformly loaded, is complicated since, as was previously derived (March, 1908, p. 84)

$$Mx = \frac{M_n + M_{n+1}}{2}$$

and the general equation for relation between moments, spans and loads of such a beam when evaluated for Mn gives

$$M_n = \frac{\frac{w_n}{4} l^2_n + \frac{w_{n+1}}{4} l^2_{n+1} - 2 M_{n+1} (l_n + l_{n+1}) - M_{n+2} i_{n+2}}{l_n}$$

and M_{n+1} is of the same general form. This procedure is prohibitive on account of its length and opportunity for error. To secure a solution and derive the value of w sought, it would be necessary to evaluate all the forms down to the center of the car and then eliminate backwards because the values of the unknown moments are met with throughout the series of equations. The equation of the formulæ showing the relative strength and stiffness of beams, referred to in the December issue, p. 457, but not worked out, will not avail any more than the value of the stress alone. Thus

$$P = \frac{EI \triangle}{L^3} k_1 \text{ for stiffness}$$

$$\text{and } P = \frac{SI}{Lc} k_2 \text{ for strength}$$

when equated give

$$\triangle = \frac{k_1 SL^2}{k_2 c}$$

The value of the deflection is thus determined, but it is in terms of the stress which leads at once to the same result as the procedure just dismissed.

Since the value of uniform load w is desired it is evident that $\triangle$ should be expressed in terms of that quantity. Each span of a continuous beam is the same as a beam with overhanging ends which in turn reduces to that of a beam with fixed ends when the overhang is the same at each end. This is the condition which obtains at the central region of the car for several spans and the use of the value of the deflection of such a beam will be very close to accuracy.

In this case

$$\triangle = \frac{1}{384} \frac{wl^4}{EI}$$

The bending moment at the middle of the span with an end load P acting with this lever arm is $P \triangle$ and the corresponding stress is

$$P \triangle \frac{c}{I}$$

where I is the moment of inertia and c is the distance to the extreme fiber of the cross section.

This is the same stress as was formerly noted to be

$$\frac{P}{A} \theta \frac{l^2}{r^2}$$

When these two values of stress are equated and the values of

$$\triangle = \frac{1}{384} \frac{wl^4}{EI} \text{ and } A = \frac{I}{r^2}$$

are substituted the value of w is found to be

$$w = \frac{384 \theta EI}{cl^2}$$

When the data in the previous article was assumed, it was the intention to present a complete mathematical calculation for the special case paralleling the theoretical exposition. Not having the necessary available time it has been deemed ample to show how the procedure should be followed to secure proper results. Upon making but a cursory examination of the car in question the value of the uniform side load coming upon the center sills, as a result of their bending, has been found to be almost four times as much as that for the vertical lading. This is under the best possible condition for sills bending in the same direction, worked out under the assumption that the end arrangement is such as to cause the end loads to be taken concentrically by the center sills. Any eccentricity would add to this value of w considerably. The same examination when applied to the total stresses upon the center sills showed that a value of l taken for the maximum span of 70 inches was too long. This would then of necessity have to be shortened, the most feasible method of so doing being to increase the width of the supported length at the transverse supports to at least 8 inches. The reactions on the floor girder will be at least four times as great as those coming upon the side girder from the reactions of the floor load transferred to it by the cross supports.

The assumption of 200,000 pounds end shock for this car carries with it the same recommendations for strength that were formerly advanced for steam service, namely—the total stresses due to the end shock and lading combined shall not total more than the elastic limit strength minus $70 \frac{l}{r}$. The value of this elastic limit should be specified in the specifications. The running of stresses up to the elastic limit applies solely to those portions of framing designed to take end shock. This means the center sills and the floor girder or truss of which the side sills are under a constant strain from being the lower chord of the side girder suporting the vertical load.

For a given value of r a reduction in l brings the allowable stress nearer to the elastic limit and reduces the column formula closer to that for a direct compression piece.

There is a characteristic of struts which can well be dwelt upon at this point, and that is the shifting of the crippling strength with the varying length. Long struts invariably fail when the elastic limit is passed. In the case of short struts experiments indicate that such is not the case. The empirical formulæ developed above seek to take into account this quality of column failure. The end shock, for which a static load equivalent has been assumed, is not a sustained force, as dynamometer experiments indicate. Indeed the peak of force application is so sharp that the stress may run high, but it will not come and go faster than the resisting stress can follow and oppose it. The end shock is thus a sudden load.

No recommendations for the tensile strength are required for the reason that, for the service to which the usefulness of this type of car has been limited, these strains are small compared to the buffing loads and can be made to come concentric with the neutral axis of the center sills. Provisions for maximum buffing strains insure ample reliability for the shocks arising from whatever pulling strains arise in service even with the deep center plate fastened to the car body.

The center sills thus fulfil the conditions of a continuous beam in both the vertical and horizontal planes, and have besides the combination flexural stress, a direct stress due to the static end load. The general moment formulæ solved for the vertical plane hold true for the horizontal, if the values of w be used as found in the above calculations. In other words, having solved for the values of vertical moments and tabulated them, the corresponding horizontal moments may be written down as that proportion of the vertical moment as the uniform side load is of the uniform vertical load.

In order to meet the condition that the struts must fail in their main members, the connections between the transverse supports must not only be rigid as before noted, but must take care of the reactions due to the lading in the two perpendicular planes. These reactions are to be found in various ways from the data already worked out. The value of the reaction is the same as the value of the adjacent shear which is of great assistance when

plate girders are used, as the shears are needed to examine the girder. They may also be solved from the moment formulæ—that is, by taking moments about the various points of support in succession.

$$\text{Thus } R_1 l_1 - \frac{w_1 l_1^2}{2} = M_2$$

which may be solved for R_1.

Likewise

$$R_1 (l_1 + l_2) + R_2 l_2 - w_1 l_1 (\frac{l_1}{2} + l_2) - \frac{w_2 l_2^2}{2} = M_3$$

from which R_2 may be found after R_1 is known.

This procedure when continued up to the center of the car will give all the reactions sought. No matter which way they are secured the total values should add up to the same amount as the total imposed load.

When these vertical reactions are found a procedure similar to the one used for finding the horizontal moments will give the horizontal reactions.

Were it not necessary that these reactions be used to secure the values of the strains imposed upon the floor and side girders, the investigation could cease after the longest span with the most destructive vertical moment had been investigated.

TRANSVERSE SUPPORTS.

After these reactions are found and tabulated the data is given upon which the design of the transverse supports is based. These supports are then first—a simple beam with a central concentrated load, and second—a strut with an end load corresponding to the horizontal reaction; the horizontal reaction generally being the greater.

Care must be taken in the design to prevent this horizontal component of the total load from acting eccentrically to the center and side sills. The nature of these secondary stresses produce a number of evil effects. If the center sills are fastened to the supports but at the lower flanges there is a twisting moment set up in these sills which produces an unnecessary torsional stress within them. If the transverse supports be loaded eccentrically there is a bending action set up in them which would help to increase their existing bending moment and thus transfer a greater reaction to the side girder in a vertical plane, to be added to the weights of the superstructure.

To provide for construction which makes these secondary stresses possible requires additional weight and should be avoided as far as possible. The stiffness of the transverse supports in the vertical plane is of paramount importance. They must not be weak so that the center sills are allowed to sag under their load, else the condition would obtain of having the end shock acting upon the center sills with a vertical lever arm which will increase the stress at a very rapid rate since the end load is measured in 100 thousands of pounds at a maximum and not hundreds, as is the vertical load. The illustration* is not intended to be a mechanical working out of these ideas; this will come when the design previously referred to appears.

The transverse support must then be secured against its tendency to translation in the horizontal plane as well as the vertical. Fixing its ends to serve this need makes of it the strut spoken about above. These points of support are to be found only in the side sill angles and diagonal bracing or in a floor plate together with the side sills. This introduces a feature of design for cars with weak center sills to absorb end shock that is acting in most cars, though not always at its best, because this function of the transverse bracing has frequently been overlooked and fullest advantage not taken of its possibilities.

The value of the floor girder in a transverse horizontal plane is also worth studying.

FLOOR GIRDER.

This resisting framing element is a vertically shallow plate or trussed girder, the nature of which makes it not capable of sustaining a great end load without undue deflection or bending. Its resistance is not due to any large degree of rigidity in its longitudinal direction, but from the fact that it takes the reacting resultant of bending strains from the center sills in the transverse plane. This floor girder is called upon to perform the function outlined whenever the center sills are weakest transversely. When, on the other hand, the stress on them from the vertical lading is so severe that the introduction of a buffing shock makes them weakest vertically, then this load is carried through the transverse supports to the side girder as a vertical reaction and the side girder assumes to absorb it as a concentrated load coming upon it. In neither case is it proper to assume that the end shock is taken longitudinally by either floor or side girder.

The essential feature of this floor girder is that the center sills and side sills must preserve their relative alignment at the points of support for all loads coming within the assumed maximum. This may be accomplished in various ways.

Trussed Floor Girder.—The use of diagonal braces so connected that they form a trussed girder with the two side sills as extreme chords and the center sills as intermediate resisting bodies is a light and rigid construction. It may be braced by diagonals or formed as a Pratt truss with single inclines at the ends and crossed diagonals in the center. The Howe truss is not as well adapted to the purpose. Other considerations being equal the truss must be one in which the members at right angles to the center sills are compression members and the diagonals tension bars, for the least weight.

The same remarks as to the eccentricity of stress transference apply at the points of attachment of these diagonals as to the connections between the supporting struts and the center or side sills. For such secondary stress avoidance the center lines of action of all forces must pass through a common point. The truss arrangement outlined above requires that the separate center sills be connected rigidly to one another at the point of support. Since the transverse supports connect the bottom, this requirement is satisfied if the sills be connected by a plate in this region, the width and depth of which are capable of sustaining half the local reaction, since the other half is taken through the bottom connection.

The calculations for this truss are made as for any framed structure, either algebraically or graphically passing from joint to joint. The data upon which the solution is based consists of the values of the reactions previously found to exist at the points of transverse support. It should be noted that the side sills are strained by the vertical lading and the stresses dare not run up to the elastic limit for this member, since here the question of stiffness as well as strength is of vital importance.

Plate Floor Girder.—The whole floor may be covered by a plate which must be secured to the side sill angles for its extreme members, to the transverse supports as web stiffeners and to the center sill members as central resisting bodies. This type of girder will transfer the loads to the side sills quite differently than the trussed girder. In this case the loads are put upon the side sills as uniform and their destructive influence is lessened, though it will be at an increased expenditure and weight. The use of plates not securely fastened to the center and side sills does not alter the condition very much from that of a trussed beam. With a plate girder the transverse struts need not be designed as strong as in the truss for the load carrying in the horizontal plane, since here they simply serve as web stiffeners to prevent the buckling of the plate under the action of the transverse shears. This web plate can be assumed to simply provide for these shears and the four longitudinal chords to provide for the tensile and compressive forces due to the bending moment. This, however, is not quite true, since the web does sustain a portion of the acting moment in just such ratio as the resisting moment of the web is to the total resisting moment of the girder. The method of analysis of this plate girder is based upon the above hypothesis together with the assumption that the vertical shearing strains in the web are of a constant value from the top to the bottom. These shearing stresses are the productive agents of the bending moments and are not quite constant throughout the depth of the web.

(To be continued.)

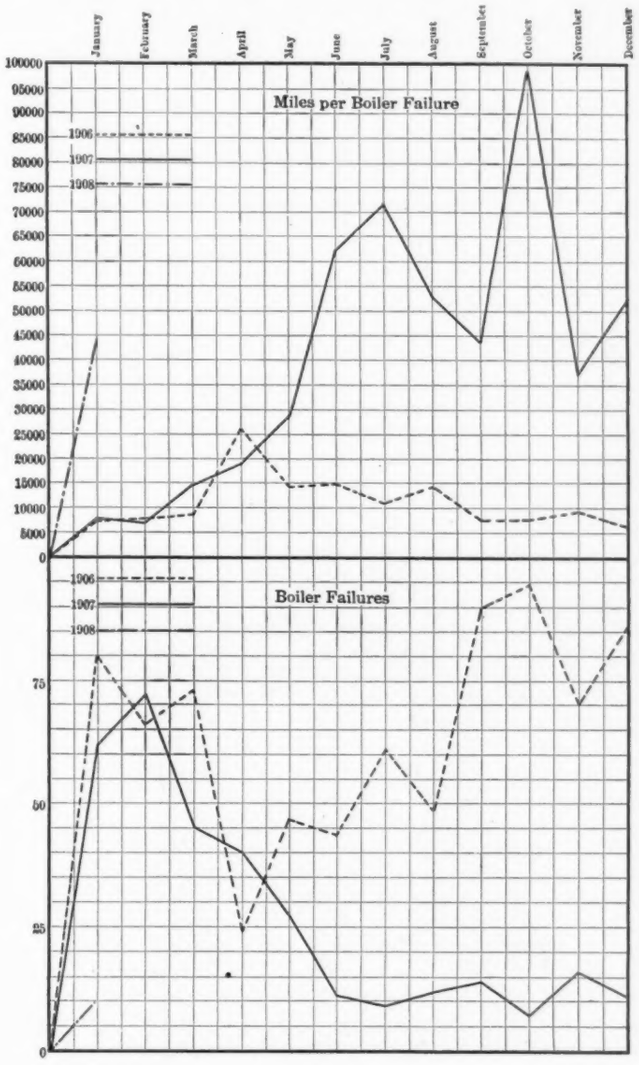
* Will appear next month.

REMARKABLE RESULTS IN LOCOMOTIVE BOILER MAINTENANCE.

The accompanying diagram was furnished by T. A. Foque, mechanical superintendent of the Minneapolis, St. Paul & Sault Sainte Marie Railway, and shows a remarkable improvement which has been made on that road during the past year, as regards locomotive boiler failures. The way in which these results have been accomplished can best be explained by quoting extracts from a letter recently received from Mr. Foque:

"The blue print shows the record of boiler failures during the years 1906 and 1907. The results were obtained largely by the use of a boiler compound.

"Perhaps the most remarkable results have been obtained on that division where we have run a heavy decapod engine for one year at a cost of 26c. for boiler work. Under previous conditions the cost of boiler work would have amounted to several hundred dollars and the fire-box would now be in bad condition. The interior of the boiler, however, may be called perfectly clean and the fire-box and flues show no signs of having been in service.



RECORD OF BOILER FAILURES ON M. ST. P. & S. ST. M. RY.

"In the hard waters the showing has been remarkable, and as we have used the compound since last spring, I believe we can now feel that the results are permanent. The blue print shows what has been accomplished. We have engines in service in fast passenger work which were sent to the shop for fire-boxes nearly a year ago, but instead of shopping them we used the compound and have had no trouble with them since. I am unable to predict when the fire-boxes will have to be taken out and renewed. In our bad water district it was not uncommon for us to shop engines for fire-boxes after they had made from 35,000 to 40,000 miles, and the troubles we experienced with such engines long before they went to the shop resulted in innumerable delays to both passenger and freight trains. We now have such engines which have run a year, or about 60,000 miles, in which there are no signs of weakness, and I do not know how long they will last.

"You should appreciate, too, that on September 14th, 1907, our boilermakers went out on a strike and are out yet, although the strike was officially declared off about a month ago. We were in such shape, however, that we did not see the necessity of taking back the old men.

"I am almost afraid to make public my views regarding the use of this compound. In all my experience I have never seen a compound which, used in a locomotive boiler, would give lasting and beneficial results, and I think that mechanical men throughout the country hold the same opinion regarding such materials as I do. We cannot, however, go back of facts, and with this particular compound my prejudices have certainly been overcome.

"We take the scale out of a boiler without making the boiler leak during the process and then we keep it out. We are not doing one-third of the roundhouse boiler work that we did before we used this material and, unless something unforeseen happens, I cannot see why our back-shop work should not show a similar decrease when we have the engines with weak fire-boxes put in thorough repair.

"This compound has been used on other roads, but I think in no case with the success which has attended its use here. One reason for this undoubtedly is the prejudice which exists against such compounds. It took a lot of hard work to have it used as directed, but when once the system was established and all concerned saw the benefits to be derived, there was no more trouble and I do not believe there is an employee in the mechanical department who does not hold the same opinions regarding the material that I do.

"There is but one way to use it. The suction pipe of one injector must be tapped and fitted with a valve to which a hose is attached, so that the solution may be drawn directly into the boiler through the injector. This is only necessary at terminals, and the engineer need not be concerned about it while on the road.

"I watched our experiments for some months with considerable anxiety, for fear that we might find something which would prohibit its further use, but on some engines we have used it for over a year and cannot discover a single objection to it. This compound is furnished to us by the H. W. Johns-Manville Company."

PERSONALS.

R. F. Kilpatrick, superintendent of motive power of the Delaware, Lackawanna & Western R. R., has resigned.

George S. Hunter has been appointed master mechanic of the Kansas City Southern Ry., at Pittsburg, Kan.

T. F. Carberry has been appointed master mechanic of the Missouri Pacific Ry. at Fort Scott, Kan., to succeed J. J. Reid, transferred.

B. J. Farr has been appointed master mechanic of the Northern Railway of Costa Rica, to succeed T. H. Jordan, who resigned recently.

F. S. Anthony has been appointed master mechanic of the gulf division of the International & Great Northern R. R., at Palestine, Tex.

George A. Hancock, superintendent of motive power of the St. Louis & San Francisco Ry., has been appointed general superintendent of motive power, succeeding Mr. Nettleton, and the office of superintendent of motive power has been abolished.

J. W. Monroe has been appointed division master mechanic of the Chicago, Rock Island & Pacific Ry., with headquarters at Chickasha, Okla.

James Meehan, for many years superintendent of motive power of the Cincinnati Southern Ry., died at his home in Cincinnati, Ohio, on Feb. 28, aged 74 years.

G. T. Hatz, master mechanic of the Chicago & Alton Ry., has resigned to accept the position of superintendent of the Union Pacific shops at Omaha, Neb.

F. T. Hyndman, until recently mechanical superintendent of the New York, New Haven & Hartford Ry., is now representing the Eldo Co., 100 William St., New York City.

Wm. Gell has been appointed master mechanic, in charge of motive power, cars and shops, of the Grand Trunk Pacific Ry., with temporary headquarters at Winnipeg, Man.

E. E. Chrysler, master mechanic of the Chicago, Rock Island & Pacific Ry., at Chickasha, Okla., has resigned, and F. H. Williams, superintendent of motive power, will take charge of the shops.

G. T. Neubert, formerly master mechanic of the Kansas City Belt Ry., has been appointed master mechanic of the Chicago Great Western Ry. at Oelwein, Iowa, to succeed W. P. Chrysler, promoted.

T. S. Lloyd has resigned as general superintendent of motive power for the Chicago, Rock Island & Pacific Ry., and has been appointed superintendent of motive power for the Delaware, Lackawanna & Western R. R.

W. A. Nettleton, general superintendent of motive power of the St. Louis & San Francisco Ry., has been appointed to the same position on the Chicago, Rock Island & Pacific Ry., succeeding Mr. T. S. Lloyd, resigned.

L. R. Pomeroy, who has been for a number of years special representative of the railroad department of the General Electric Co., has gone to the Safety Car Heating & Lighting Co., New York, as assistant to the president.

RAILWAY GENERAL FOREMAN'S ASSOCIATION.

The next annual convention of this association will be held in Chicago, May 25 to 29. The subjects to be discussed are as follows:

The pounding of the left main driving box in preference to the right—What causes the pounding and how can it be stopped? C. H. Voges, N. Y. C., Bellefontaine, O.; E. R. Berry, C., B. & Q., Galesburg, Ill.; W. H. Kidneigh, U. P., Grand Island, Neb.

Modern shop construction—Cross pits or longitudinal, location of wash rooms and lavatories. Best location for each department. Care of shop order material and convenience of storage. L. H. Bryan, D. & I. R., Two Harbors, Minn.; D. E. Barton, Santa Fé, Topeka, Kans.; L. R. Laizure, Erie, Hornell, N. Y.; E. F. Fay, U. P., Denver, Col.

Reporting work vs. engine inspection—Should either be discontinued or are both methods essential? E. B. Moore, U. P., Cheyenne, Wyo.; G. E. B. Warme, 'Frisco, Fayetteville, Ark.; A. E. Thomas, C. G. W., Olewein, Iowa; J. C. Wilkinson, C., R. I. & P., Chawnee, Okla.; E. B. Turner, C. & E. I., Danville, Ill.

The apprentice question—How can we obtain the right kind of material and how can we keep them interested? The benefit of night schools for apprentices maintained at company's expense—Does company obtain sufficient benefit to warrant this expenditure? A. O. Berry, L. S. & M. S., Collinwood, Ohio; H. J. Carrier, Erie, Huntington, Ind.; W. C. Groening, Pere Marquette, Grand Rapids, Mich.; W. G. Larmour, N. & S., Norfolk, Va.; W. Pohlenan, N. Y., O. & W., Middletown, N. Y.

The mileage of a locomotive—Its relation to cost of shop and running repairs—Does it pay to overhaul an engine that will give but 90 days flue or fire-box service? How could this be handled?—Who should determine when to shop an engine, and who should furnish the work report? E. C. Hanse, S. A. L., Savannah, Ga.; G. E. Bronson, C., R. I. & P., Colorado Springs, Col.; George Moore, International, Moncton, N. B.; E. C. Marsh, N. & W., Portsmouth, Ohio.

Why do stay-bolts break more frequently on left side? A. Bradford, Big Four, Urbana, Ill.; H. S. Brickley, E. P. & S. W., Alemogorde, N. Mex.; B. Buzzell, M. P., Poplar Bluff, Mo.; W. H. Clough, Erie, Hammond, Ind.

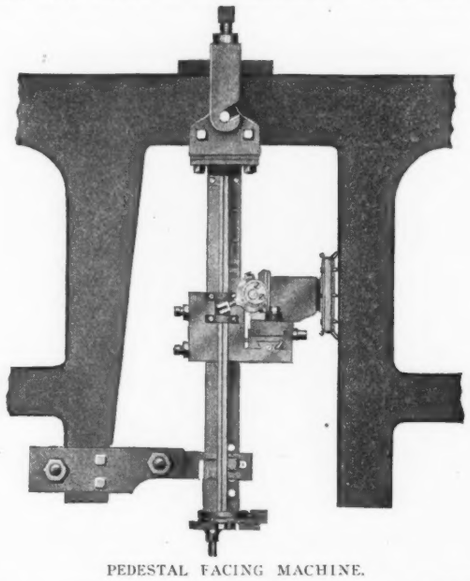
The quick discharging of engines at terminals and how to handle most economically? D. E. Barton, Santa Fé, Topeka, Kans.; G. W. Keller, N. & W., Portsmouth, Ohio; P. W. R. Mark, B. & O., Cleveland, Ohio; William Moore, Erie, Carbondale, Pa.; William Hall, C. & N. W., Escanaba, Mich.

Which is the cheaper to maintain—The piston or slide valve? W. E. Farrell, Big Four, Columbus, Ohio; Ben Beland, 'Frisco, Springfield, Ohio; Joe Claugh, 'Frisco, Oklahoma City, Okla.

LOCOMOTIVE PEDESTAL FACING MACHINE.

The locomotive pedestal facing machine, shown in the illustration, is made by H. B. Underwood & Co., Philadelphia, Pa. Its construction is simple; the method of attaching it to the frame is clearly shown in the photo. A swivel at the top of the vertical bar, which carries the milling head, allows the cutting tool to be used on either pedestal leg. The upright bar or guide can be adjusted to suit the angularity of the pedestal leg. The clamping arrangement at the top is made to suit the widest frame and can be adjusted to suit the narrower ones.

The milling head has a bronze half nut which engages the feed screw which extends alongside the upright bar or guide (at the rear in the view shown in the illustration). The feed is operated by the eccentric on the milling head which drives the square vertical shaft, which in turn drives the feed screw by a ratchet and pawl. The feed may be varied to suit requirements.



PEDESTAL FACING MACHINE.

The milling head may be quickly and accurately adjusted, as it has a motion to and from the leg and crosswise. The universal adjustable clamps at the bottom secure the device rigidly to the frame.

The spindle is threaded to receive the milling cutters; the cutting tools are of high speed steel and are removable for grinding and adjustment. The spindle is driven through gears and a telescopic shaft with universal tumbling joints at each end. If desired a two-cylinder air or steam motor can be furnished for driving the machine.

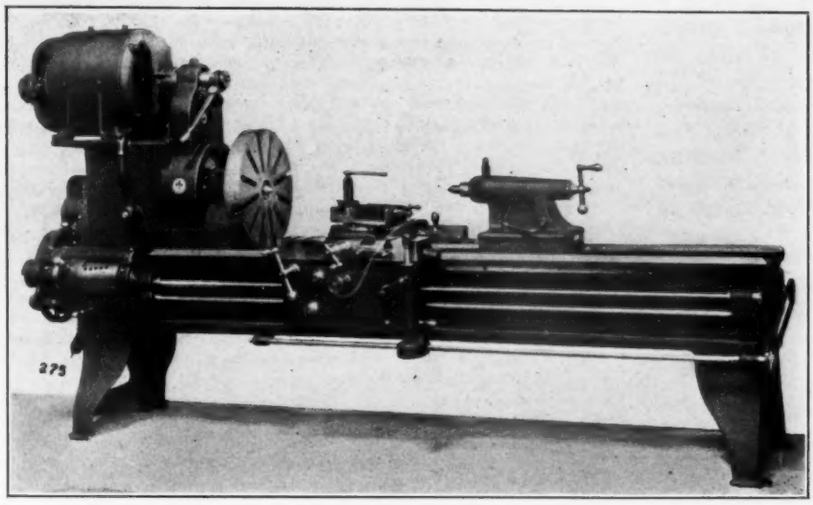


FIG. 1.—APPLICATION OF VARIABLE SPEED MOTOR TO 22-INCH LATHE.

MOTOR DRIVEN ENGINE LATHES.

The machine tool builders have all given more or less attention to the application of the individual motor drive to their tools, especially since the advantages of the individual drive, under certain conditions, have become more and more apparent. The accompanying illustrations show the standard methods of applying individual motors to The R. K. LeBlond Machine Company's (Cincinnati, O.) lathes.

A typical application of a variable speed motor to lathes, up to and including 22 in. swing, is shown in Fig. 1. The headstock has pads cast on the sides, which are planed to receive the motor bracket, or housing. Motors of any make can thus be attached in a neat and substantial manner. A clutch pinion on the motor shaft drives a rawhide gear which runs loose on a 1¾ in. pin, reduced to 1½ in. in diameter where it passes through a bracket cast on the motor housing to which it is held by a nut on the inner side. Only a small portion of this bracket can be seen in the illustration, although the outer end of the pin with an oil hole cap in its center shows clearly.

The rawhide pinion drives a sleeve gear on the spindle which may be locked to the face gear for direct speeds, or can drive the spindle through a double friction back gear. Three mechanical changes are thus available, independent of the motor. The gear covers are arranged to allow easy access to the gears for cleaning and inspecting, and so as not to interfere with the adjustment of the spindle and boxes. For the quick starting and stopping of the lathe, regardless of the motor, a friction clutch has been arranged in the motor pinion and is operated by the long handle at the end of the motor shaft. This device is of considerable advantage when it is necessary to start and stop the machine frequently; without it the lathe stops slowly because of the momentum of the heavy motor armature. The friction clutch is of simple construction, consisting of a bronze ring which is expanded in the periphery of the pinion by a taper wedge or key.

The LeBlond double friction back gear provides, through the lever at the front of the motor bracket, instant speed changes from high to low back gear, without changing a gear and while the tool is running. The back gear is arranged to give a continuous speed range with a 3 to 1 motor; if the motor is operated on the multiple voltage system, the lower voltages are not required, resulting in a more powerful drive, or making possible the use of a smaller motor.

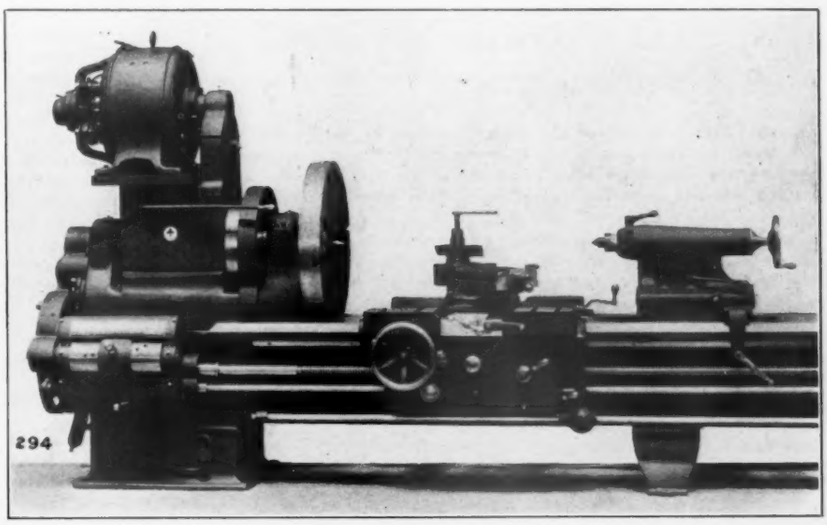


FIG. 2.—APPLICATION OF VARIABLE SPEED MOTOR TO LARGER LATHES.

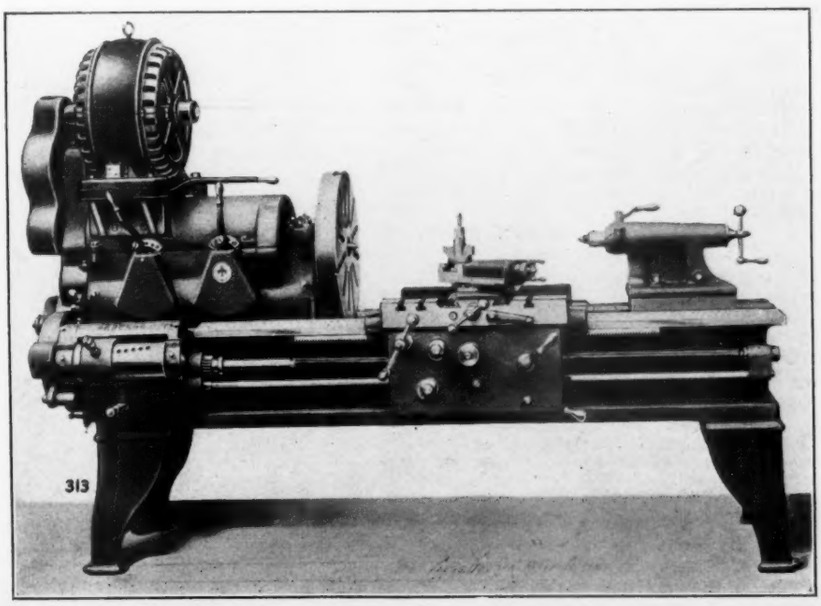


FIG. 3.—APPLICATION OF CONSTANT SPEED MOTOR TO LATHE.

The motor controller is of the drum type, and is bolted to the back of the lathe bed at the tailstock end. It is operated by a handle on the carriage, through a set of gears, a splined shaft and chain drive, as shown.

On the larger lathes, which require a greater speed range, the motor is applied as shown in Fig. 2. The motor pinion drives a rawhide gear, mounted on a short shaft, with bearings in the gear cover case. The rawhide gear drives a double friction shaft above the spindle and mounted in the motor bracket. This provides four mechanical speed changes. The motor controller is applied as in Fig. 1.

The method of applying a constant speed motor is shown in Fig. 3. The motor is mounted on the headstock and the drive is through a rawhide intermediate gear to the shaft on which are mounted the double friction gears. These frictions are of the standard LeBlond type, are automatic in adjustment and are operated by a lever conveniently located for the operator. This gives two changes of speed, as well as means for quickly starting and stopping the lathe, independent of the motor. The lower shaft has a set of sliding cone gears which multiply the speeds, giving a total of twelve changes. The lathe has no back gears or lock-nut to be engaged, and the entire range of speed may be obtained while it is running. All gears are made of steel; the teeth have beveled edges and are hardened. Those running at a high peripheral speed are engaged with a clutch. The arrangement throughout is very compact and substantial and the gearing is calculated for hard and continuous service.

ANOTHER WORLD'S FAIR.—An international exhibition of industries and labor will be held at Turin, Italy, in 1911. It will celebrate the fiftieth anniversary of the Kingdom of Italy.

HIGH PRESSURE STEAM IN LOCOMOTIVE SERVICE.—The extensive researches of Dr. W. F. M. Goss to determine the value of high steam pressure in locomotive service, which were conducted under the patronage of the Carnegie Institution of Washington, have now been published and can be obtained from that institution at a price of $1.25 per copy.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

SCREW CUTTING TOOLS AND MACHINERY.—The E. F. Reece Co., Greenfield, Mass., is issuing Catalog No. 6, which includes illustrations, tables of capacities and sizes and a brief description of the very complete line of taps and dies and screw cutting machinery, manufactured by it.

FIBRE CONDUITS.—The Fibre Conduit Co., Orangeburg, N. Y., is issuing a couple of leaflets briefly pointing out the many valuable features of this very light non-conductive insulating type of conduit, which in practical work is found to have many very important advantages.

INSTRUCTION PAMPHLETS—TRIPLE VALVES.—The Westinghouse Companies Publishing Department is issuing instruction pamphlets, each of which contains fully illustrated descriptions of the construction and operation of triple valves, there being one on the type L triple valve for steam trains, and one on the type M triple valve which is used for electrically propelled trains in high speed service.

SMALL CAPACITY MOTORS.—The Emerson Electric & Mfg. Co., St. Louis, Mo., is issuing two new bulletins, one showing electric forge blowers, comprising a centrifugal blower with the direct connected motor for either direct or alternating currents, which are equipped with speed regulators and are built in capacities of 150, 300 and 400 cu. ft. of free air per minute. The other bulletin is on the subject of bi-polar ventilated motors of 1/3 and 1/2 h. p. capacity, designed for direct current.

EFFECT OF BRAKE BEAM HANGING UPON EFFICIENCY.—The Westinghouse Air Brake Company is issuing a pamphlet containing a reprint of a most extensive and complete paper on the above subject, presented by Mr. R. A. Parke before the New York Railroad Club on November 18, 1897. The introduction of this pamphlet states that the recommendations of this paper have been followed out in practice with most excellent results and it is considered that the importance of the fundamental principles laid down by the author is sufficient to make it advisable to issue this reprint.

ELECTRICAL MACHINERY.—The General Electric Company is issuing a number of new bulletins among which might be mentioned No. 4548, which shows typical examples of direct and alternating current motors installed on a great variety of lathes, drills, grinders, shears and similar tools, which illustrate the great adaptability of these motors for this class of service. Following a short description of the motors and controllers there are about 15 pages of excellent half-tones. Other bulletins are being sent out on the subjects of fan motors, Tungsten, Tantalum and Edison "Gem" incandescent lamps, as well as flaming arc lamps.

REACTION is the title of a new quarterly publication devoted to the science of Aluminothermics, which is being published by The Goldschmidt Thermit Co., 90 West St., New York. This is a technical publication in every sense of the word and gives some very interesting illustrations and most valuable information on aluminothermics. An introductory paragraph states that this book is not being issued to give publicity but simply to keep the engineering world in touch with the best and most up to date practice in welding, which is constantly undergoing improvement. It will be sent free of charge to any one in the U. S., Canada or Mexico.

BUDA WATER SOFTENERS.—The Buda Foundry & Mfg. Co., Chicago, is issuing Bulletin No. 120 which fully illustrates and describes the Buda intermittent and continuous systems of water softening for use in connection with railroad water stations and power plants. It has been the aim of this company in deciding upon the features of its system to secure simplicity, elimination of moving parts, large capacity and such construction as would make it practically impossible to have any interruption of the operation of the plant, even when handled with very low grade labor. The bulletin fully illustrates and describes the system and gives a number of very interesting illustrations of recently installed plants.

SINGLE PURPOSE LATHES.—The Fitchburg Machine Works, Fitchburg, Mass., is issuing a very attractively arranged catalog which fully illustrates and describes the valuable features of its new "Lo-swing" lathe. This tool has been designed for the purpose of furnishing a highly specialized machine for a particular class of work. It does only turning on centers, is not arranged for screw cutting or chucking and is limited to a maximum turning diameter of 3½ in. and a working length of 5 ft. The whole machine is designed to do its own particular highly specialized work to the very best advantage and with the greatest rapidity and accuracy. The details of construction and examples of the kind of work the machine is capable of doing are clearly illustrated.

UNDERFRAME AND TRUCK EQUIPMENT.—A catalog, consisting of a collection of blue prints, giving very well executed perspective views of the different pieces of equipment manufactured by it, is being issued by the Pittsburg Equipment Company, Pittsburg, Pa. The products of this company consist of cast steel parts for car underframes and trucks, comprising many new designs of bolsters, both body and truck, draft sills, end sills, oil boxes, side frames, spring planks, etc. Some very ingenious arrangements are shown for the combination of cast steel body bolsters with structural steel center and side sills, the arrangement being such as to permit a convenient removal of different parts while retaining full strength and using very few separate pieces and bolts or rivets. These bolsters are shown in a number of different designs for various capacity cars and different conditions of service. Arrangements of combined cast steel draft sills and body bolster for any type of draft gear, which are so constructed as to be easily applicable to cars with either wooden or steel sills, and having the construction either integral or separate as desired, form a very interesting part of the catalog. Complete underframes for cars of different capacities employing cast steel bolsters, draft sills and end sill, and structural steel for the remaining parts, are also illustrated. Several designs of cast steel side frames illustrate that the possibilities of introducing new and valuable improvements in this important part have not previously been exhausted. The constructions shown in this catalog are novel and practicable.

NOTES

DEARBORN DRUG & CHEMICAL WORKS.—Mr. George R. Carr, vice-president, is on a combination business and pleasure trip to the City of Mexico.

LOCOMOTIVES ORDERED.—The American Locomotive Company has recently received an order through Elberton D. Hitch & Co. for two 2-4-0 type locomotives, with 9 x 16 in. cylinders, for service in Brazil.

WISCONSIN ENGINE COMPANY.—This company announces that it has established a branch office at Atlanta, Ga., under the management of Mr. Julius M. Dashiell, who will be located in the Chandler building.

BETTENDORF AXLE COMPANY.—This company has received an order for steel under-frames equipped with Bettendorf cast steel trucks and swing motion bolsters for 2,500 stock cars from the Chicago, Milwaukee & St. Paul Railway.

T. H. SYMINGTON COMPANY.—Mr. E. H. Symington, who recently returned from an extensive trip in Europe and the far East, has again departed for a foreign tour which will take in South Africa, South America, Australia and New Zealand.

WESTINGHOUSE GAS ENGINES.—The Duquesne Steel Foundry, which operates a large plant in the Pittsburg district, has decided to adopt the gas power system for operating its works formerly driven by steam. The plant will consist of a 400 h. p. Westinghouse three-cylinder gas engine direct connected to a 240 k. w. generator. Natural gas will be used.

A. S. M. E.—The American Society of Mechanical Engineers, with a desire to still further develop their publication, have secured Mr. Lester G. French to direct the editorial department. One of the first improvements to be made will be the establishment of departments in the monthly proceedings. Mr. French, following an extensive experience in practical work, was for nine years editor-in-chief of *Machinery*.

A NEW LOCOMOTIVE BELL.—Visitors at the mechanical conventions last year will remember the pleasing tones of a chime of bells which formed part of the exhibit of the National Tube Company. These bells were made of Shelby seamless steel and are formed from a seamless steel tube. They give an excellent tone, are practically nonbreakable and are now being put on the market for use on locomotives. Information concerning them can be obtained from the National Tube Company, Pittsburg, Pa.

BURNING LIGNITE COAL IN LOCOMOTIVES

By O. N. Terry.*

In certain sections of this country the sub-bituminous and lignite coals are practically the only fuels available. The coal mined in the vicinity of Sheridan, Wyoming, is a sub-bituminous coal, but is commonly called lignite,† and where the word lignite is used in this article it should be understood to mean Wyoming or Northern Colorado coal, which in many respects is superior to the average bituminous coal. It is light and clean and almost entirely free from slate or rock. It ignites quickly and burns freely with practically no clinkering, when properly handled. It differs from the bituminous principally in the amount of moisture and ash, the moisture being usually higher than with bituminous coal and the ash lower. When exposed to the sun and air it soon begins to slack and break up into small cubes, which eventually crumble into powder. It is therefore advisable to put it on the locomotive tender without any unnecessary delay after it is mined.

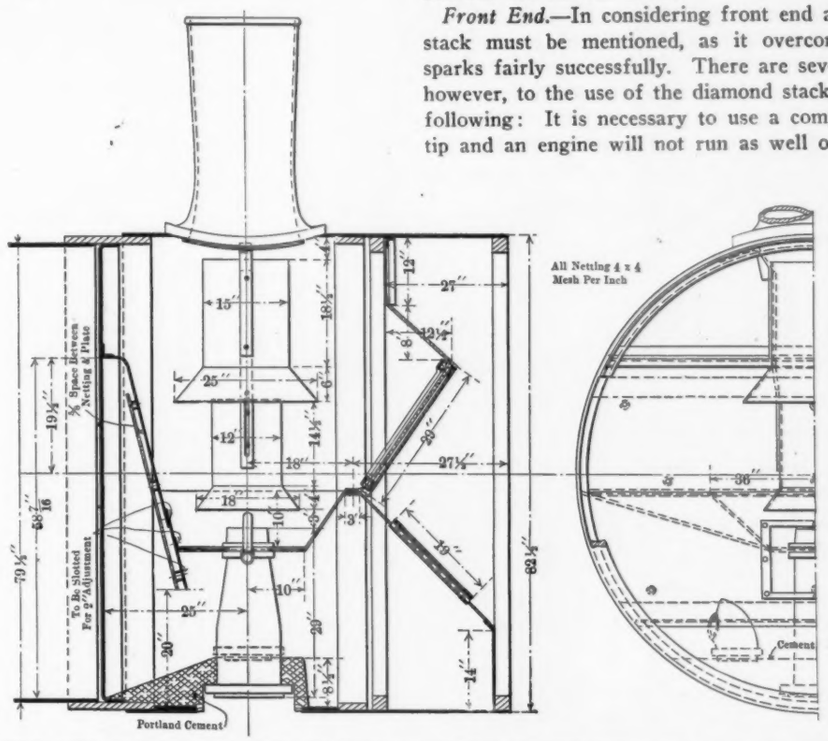


FIG. 2.—FIRST FORM OF FRONT END WITH STRAIGHT STACK USED FOR BURNING LIGNITE ON THE BURLINGTON.

Lignite does not coke when burning, but breaks up into small pieces which are kept moving by the draft when an engine is working hard. As these particles burn, and decrease in size, they eventually reach a point where the draft is strong enough to carry them up, over the arch, through the flues and out of the stack. It is a peculiar property of lignite that these small pieces generally burn until they are entirely consumed, and it is necessary that they be reduced to a very small size before they are permitted to escape. It is therefore apparent that the importance of adequate spark arresting appliances is greater than with bituminous coal. The ash pan should be as tight as possible without any direct openings below the level of the mud ring, that are not covered by small mesh netting. Sufficient air opening may be secured by extending the sides of the ash pan out beyond and slightly above the lower edge of the mud ring, or by leaving space between the ash pan and the mud ring, which is covered with netting.

Grates.—The grate shown in Fig. 1 has proved to be very satisfactory for lignite. It was originally designed with the idea that the increased air opening would reduce the amount of fire lifted from the grates. It is impossible to determine if it has had such an effect, but other advantages, such as simplicity, cheapness, durability, fewer connections, reduction of engine failures, etc., have made it a success.

Brick Arch.—It is generally the practice in burning lignite coal to use a large arch so that the sparks and gases will be consumed before going into the tubes. This should be fitted tightly against the flue sheet and there should be no holes in the arch between the various bricks.

Front End.—In considering front end appliances the diamond stack must be mentioned, as it overcomes the trouble from sparks fairly successfully. There are several serious objections, however, to the use of the diamond stack, among which are the following: It is necessary to use a comparatively small nozzle tip and an engine will not run as well or handle as much tonnage as it otherwise would. The diamond stack is disagreeable to the enginemen on account of fine cinders coming down around and inside the cab. It is expensive to maintain as the cone, netting and top part of the stack cut away rapidly. This of course makes it correspondingly difficult to keep the stack in safe, serviceable condition.

The first form of front end arrangement used with a straight stack on the Burlington road for burning lignite is that shown in Fig. 2. In this arrangement 4 x 4 mesh, No. 12, wire netting was used, coming forward from the diaphragm on the level of the nozzle tip. About half way between the nozzle tip and the front end one layer of netting ran down to a point about even with the lower part of the door opening, and another netting extended up in a zig-zag form to the top of the smoke box. A layer of netting, with an open basket or flare, extended up around the nozzle tip. When both of the front end nettings were clean the majority of the sparks would strike the lower front netting and pass up through the second netting. Generally, however, after running a short distance the upper front netting would stop up with cinders and cinders would accumulate under the lower front netting, frequently causing it to burn out. Upon

* Chief Draftsman, Burlington Lines West of Missouri River.

† Lignite from the Wyoming Coal Mining Company's mines, at Monarch, Wyoming (Sheridan Co.), on the Burlington & Missouri River Railroad, was tested at the coal testing plant of the United States Geological Survey, at the Louisiana Purchase Exposition, St. Louis. The proximate analysis of this coal was as follows:

Moisture	21.97 per cent.
Volatile matter	35.95 " "
Fixed carbon	37.75 " "
Ash	4.32 " "

The calorific value is about 9,700 B. T. U.

opening the front end door and removing the trap doors in the netting, it would be found that the single layer of netting around the nozzle was perfectly clean. It is, therefore, safe to say that this arrangement was practically a single netting front end of 4 x 4 mesh, No. 12, wire.

With this front end arrangement double petticoat pipes were used and the engines in general gave very good results. The netting, however, from a lignite standpoint, was rather coarse, and as it was difficult to keep the joints between the netting and smoke box in good condition, it was not entirely satisfactory.

The next step was an attempt to use two complete layers of 4 x 4 mesh netting with an inside extension stack built on the lines recommended by the Master Mechanics' Association. One engine was fitted up with two layers of 4 x 4 mesh netting, 5 in.

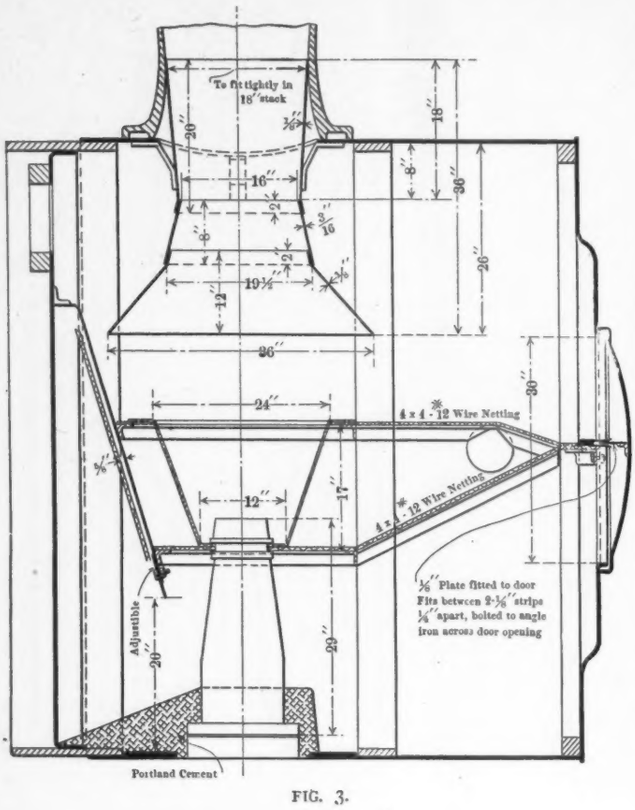

To fit tightly in 18" stack
4 x 4 - 12 Wire Netting
4 x 4 - 12 Wire Netting
⅛" Plate fitted to door
Fits between 2-⅛" strips
⅛" apart, bolted to angle
iron across door opening
Adjustible
Portland Cement

FIG. 3.

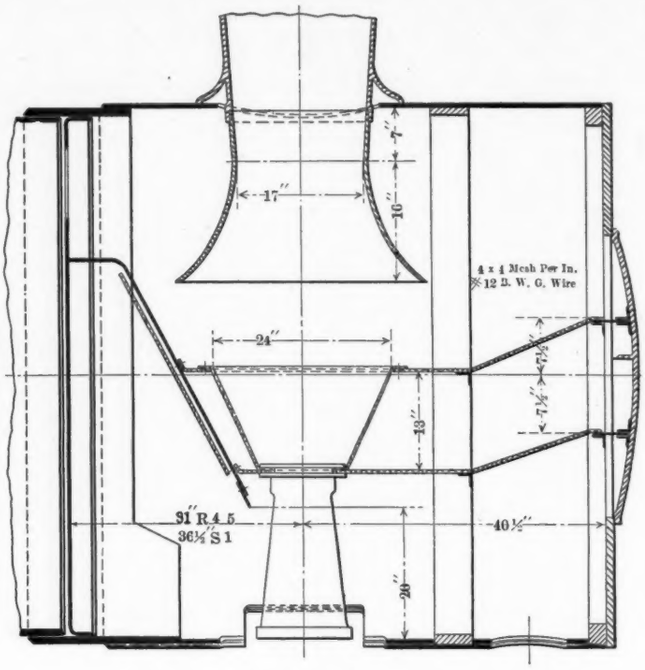


FIG. 4.

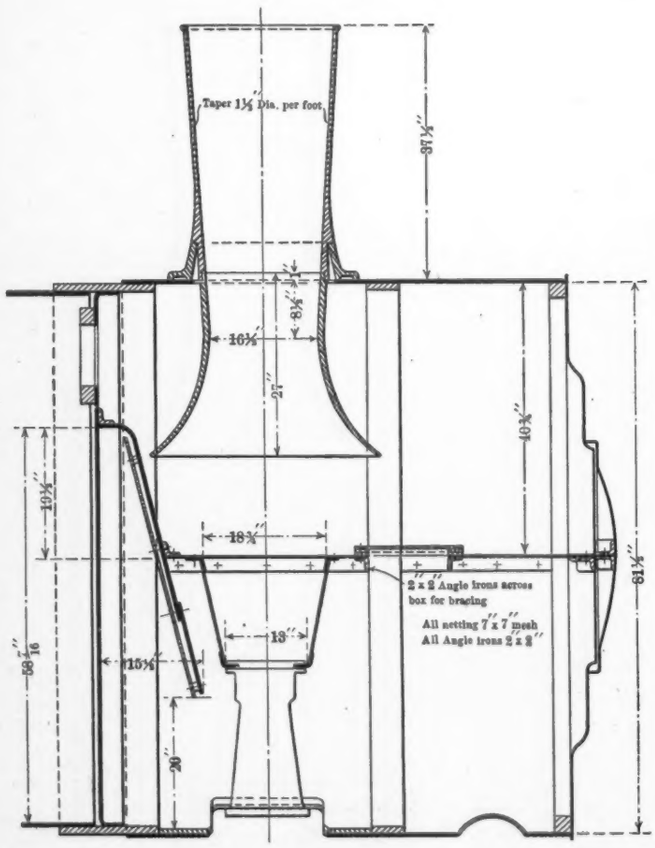
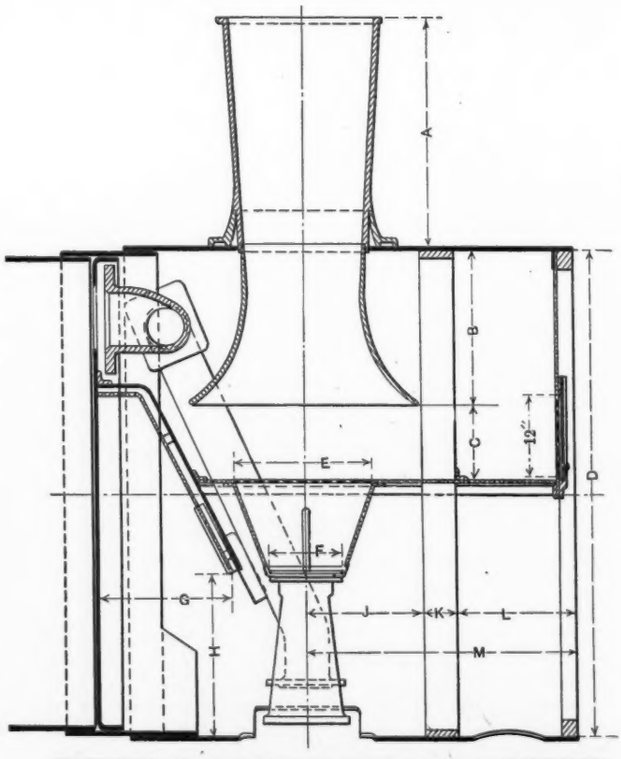


FIG. 5.



Class	A	B	C	D	E	F	G	H	J	K	L	M
R-4, R-5, S-1	45½"	28"	11"	73"	19"	13"	20"	24"	17⅛"	5"	18"	40½"
D-4-A, D-4-B	37½"	26"	12½"	81½"	20"	13"	15½"	20"	15½"	5"	22 1/16"	45 9/16"

Use 4½ x 4½ Mesh № 12 B.W.G. Wire on Diaphragm Plate
" 7 x 7" " № 16 " " " " in Basket & rest of Smoke Box

FIG. 6.

STAGES IN THE DEVELOPMENT OF FRONT ENDS FOR BURNING LIGNITE ON THE BURLINGTON.

apart on a straight incline from the nozzle to the front top part of the smoke box, but the second or top layer of netting caused trouble by stopping up. Later an engine was fitted up in practically the same manner except that perforated plate was used instead of netting. This engine was very successful from a steaming standpoint, but the holes in the perforated plate were too large for lignite coal.

Several engines were fitted up, as shown in Figs. 3 and 4, and gave fairly good results. By keeping the two layers of netting about 12 in. apart the tendency to clog up the top netting was greatly reduced. It was gradually demonstrated that very little was gained by using two complete layers of netting. The Master Mechanics' stack, however, proved to be a decided success. It was noticed that the bottom layer of netting usually remained clean while the top layer clogged up more or less, even in the free steaming engines. It was, therefore, decided to try 4½ x 4½ mesh, No. 12, wire netting for the bottom layer as it was thought that this would reduce the fire throwing and also prevent the upper netting from stopping up. The fire throwing was undoubtedly reduced, but the top layer of netting continued to stop up, even though the individual openings were about 35 per cent. larger than those in the bottom layer. It became apparent that the second or top layer of netting was of very little value and was decidedly objectionable on account of its tendency to clog

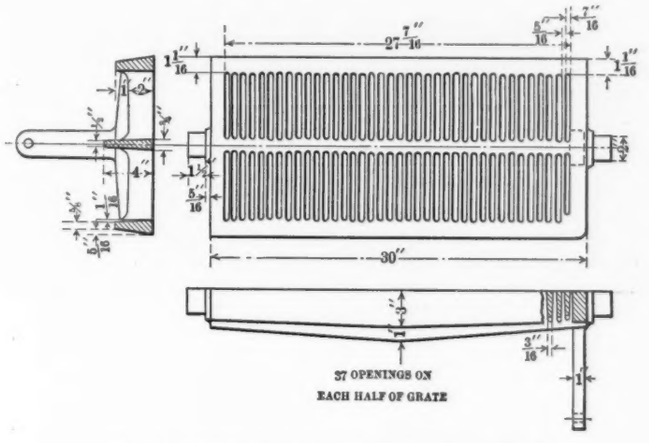


FIG. 1.—GRATES FOR LIGNITE BURNING ENGINES.

up. An engine was accordingly fitted up, as shown in Fig. 5, with 4½ x 4½ mesh, No. 12, wire netting which gave quite favorable results. Another engine was fitted up with 7 x 7 mesh, No. 16, wire netting which gave better results than the 4½ x 4½ mesh, No. 12, wire, both in reducing fire throwing and the tendency to clog up.

Considerable difficulty was experienced in maintaining tight joints between the netting, and front end plate and door, and the design shown in Fig. 7 was made to overcome this trouble. This design with 7 x 7 mesh, No. 16, wire netting gives very good results, but the netting sometimes clogs up with poor, wet slack coal, or when there is a leak of steam or water in the front end, which permits moisture to come in contact with the netting. The same trouble has been experienced with the 4 x 4 mesh, No. 12, wire netting but to a much less extent.

With the Master Mechanics' stack splendid results are obtained in the way of draft. Mechanically it is much superior to any contrivance involving single or double adjustable draft pipes and eliminates engine failures on account of "draft pipes loose," "draft pipe out of line," etc. It has been observed that the netting directly under the flare or bell of the stack remains clean while the netting near the front end door has some tendency to stop up. Horizontal netting does not stop up as readily as does netting which is set on an incline, with this type of stack, and small mesh netting with small wire is better than small mesh netting made of large wire.

In burning lignite exceptional care must be taken in equipping and maintaining the front end appliances, so that there are no holes around the edges where the netting comes against the smoke box, steam pipes, etc. It is practically useless to apply fine mesh netting or spark arrester sheets to a smoke box unless the work is very carefully done. A small crack or space which would not be noticed on a bituminous burner would not be safe on a lignite burning engine. Simplicity, ease of inspection and accessibility for cleaning and repairs are of the greatest importance. A wire brush is about the most efficient device for cleaning the netting and removing cinders which have lodged in the small spaces of the netting. The netting should be inspected and thoroughly cleaned at each end of the division.

To successfully burn lignite large grate area is more essential than with bituminous coal. On engines with small grate area the diamond stack apparently gives the best results, although it is probable that a straight stack design might be worked out. Long tubes and large grate area are undoubtedly important features in lignite burning engines, but there is considerable variation in dimensions of engines which have given good results with this fuel. One class of engines used in passenger service with heavy trains on long divisions under exceptionally severe conditions gave very good results. These were 10 wheel engines, 19 x 26 in. cylinders with 69 in. drivers, grate surface 44 sq. ft., 342—2 in. O.D. tubes, 15 ft. 1 in. long.

Heating surface,	fire-box	151.44 sq. ft.
" "	tubes	2717.94 sq. ft.
" "	total	2869.38 sq. ft.

A consolidation freight engine which gives good service has the following general dimensions:

Cylinders		22" x 28"
Drivers		57"
Grate surface		54.2 sq. ft.
Tubes		450—2" O. D. 15 ft. long
Heating surface,	fire-box	221.77 sq. ft.
" "	tubes	3511.56 sq. ft.
" "	total	3733.33 sq. ft.

A Prairie type engine which burns lignite very successfully has tubes 19 ft. long. The general dimensions are as follows:

Cylinders		22" x 28"
Drivers		69"
Grate surface		54.2 sq. ft.
Tubes		301—2¼" O. D. 19 ft. long
Heating surface,	fire-box	200.0 sq. ft.
" "	tubes	3353.4 sq. ft.
" "	total	3553.4 sq. ft.

Another consolidation freight engine which does good work with lignite is of the following general description:

Cylinders		22" x 28"
Drivers		52"
Grate surface		48 sq. ft.
Tubes		375—2" O. D. 14 ft. 8½ in. long.
Heating surface,	fire-box	171.4 sq. ft.
" "	tubes	2812.5 sq. ft.
" "	total	2983.9 sq. ft.

A Pacific type engine is now being used in passenger service which steams very freely and gives splendid results with lignite coal. This engine has 54.2 sq. ft. of grate area, 303 tubes 2¼ in. O.D., 21 ft. long, and 3932.7 sq. ft. of heating surface, 200 of which are in the firebox; drivers, 74 in. diameter.

From the foregoing descriptions it is apparent that there may be considerable difference in grate area, heating surface and length of tubes in successful lignite burning engines. The general results with 7 x 7 mesh, No. 16, wire netting are very good, especially where the engine is properly handled. There are times, however, when quite a number of small sparks are thrown out of the stack, especially if the fire door is opened when the fire is burned down, but practically all of these are burned out or dead when they strike the ground.

When considering the question of fires caused by lignite burning locomotives, it must be remembered that practically all of the trouble occurs during the dry seasons in a section of the country which has a particularly dry climate, so that even bituminous coal, if it was obtainable, would undoubtedly start more fires than it does in other parts of the country. The present straight stack with 7 x 7 mesh, No. 16, wire netting, may be fairly considered to be equal in overcoming trouble from sparks to any of the diamond stacks that have been successfully used. There is good reason to expect that improvements will be made on present designs of spark arresting appliances which will effectually remove the one objection to the use of lignite coal and establish its position as an excellent fuel for locomotives.

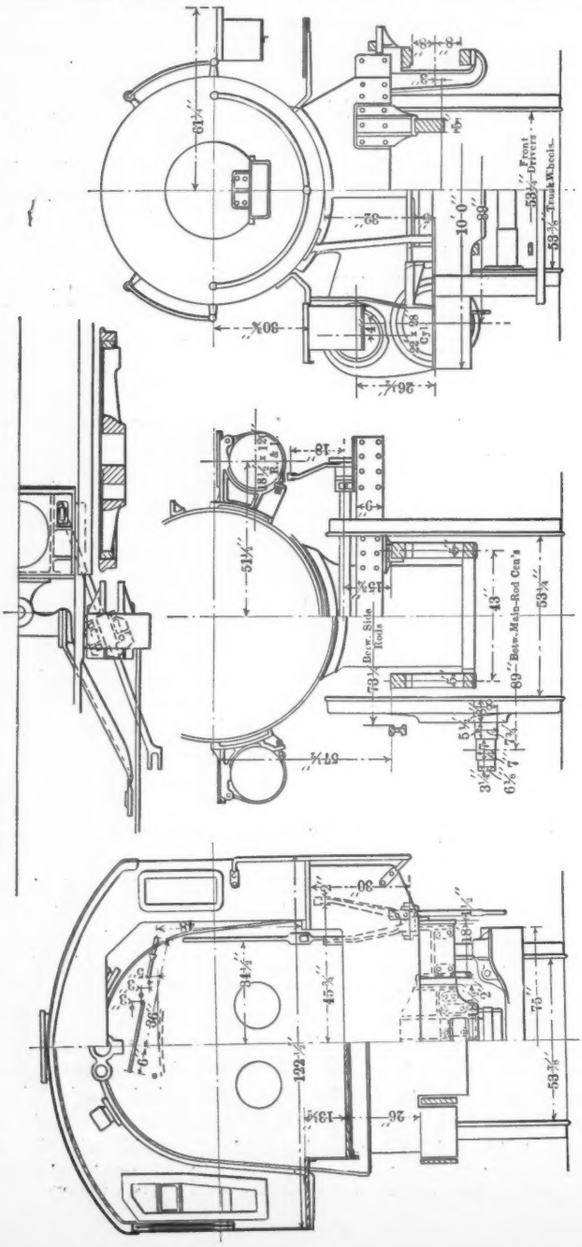
HEAVY PACIFIC TYPE PASSENGER LOCOMOTIVE.

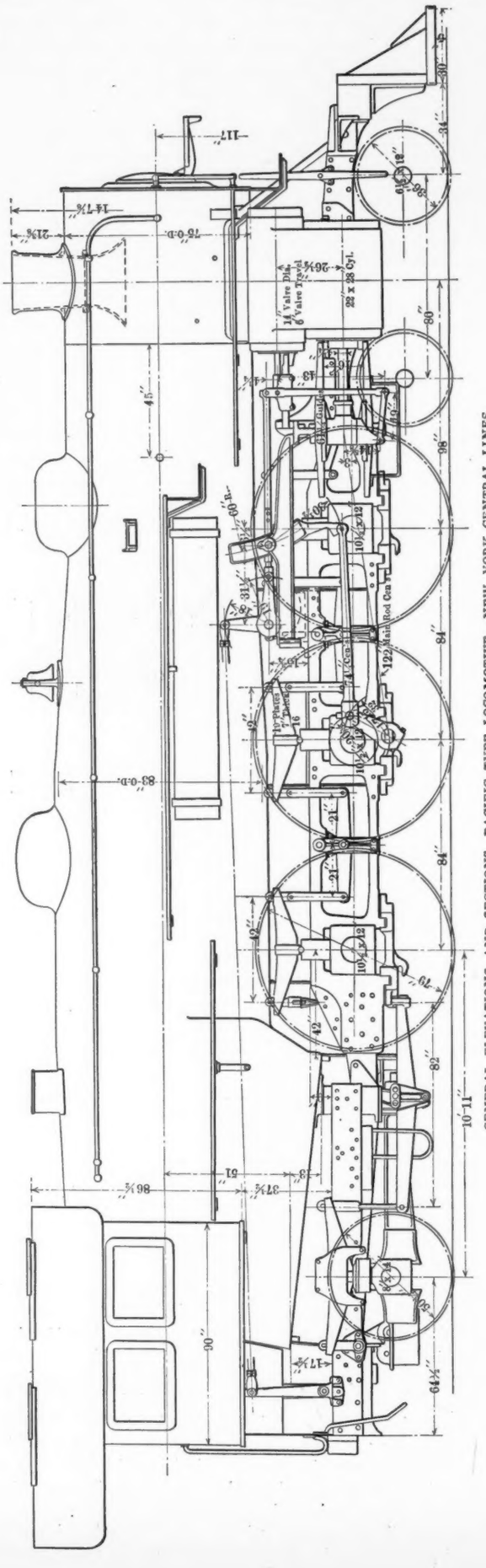
New York Central Lines.

There has recently been finished at the Schenectady Works of the American Locomotive Company, 40 Pacific type passenger locomotives for the New York Central & Hudson River Railroad, which are the heaviest ever built for this line, and are practically the heaviest passenger locomotives in the world.

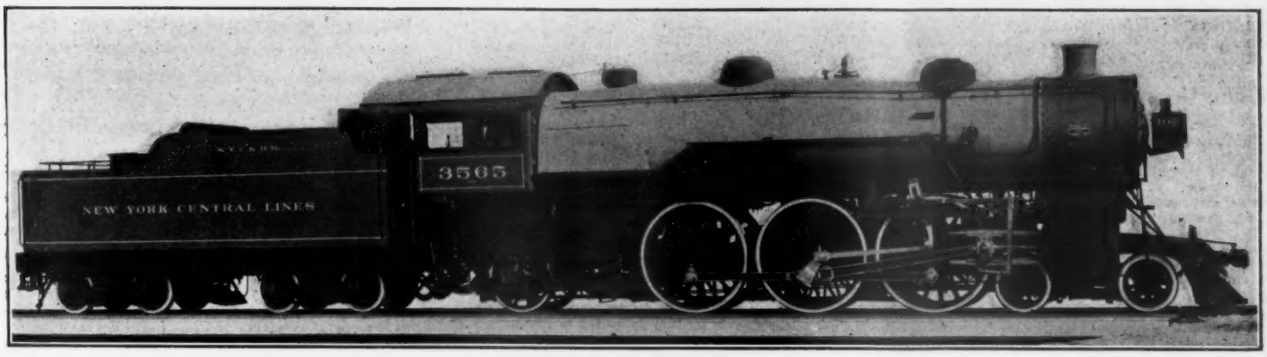
These locomotives are, in all essential details, duplicates of the 25 engines built by the same company last year for the Lake Shore & Michigan Southern Railway, which were illustrated and described on page 365 of the September issue of this journal. Those engines took the place of the Prairie type, as the standard high speed engine on that road, and are now hauling all of the heavier through trains. It is probable that this new class will become the standard type for heavy passenger power on all of the New York Central Lines.

For comparison with previous locomotives of this type, as well as other passenger locomotives, reference should be made to the tables published in connection with a description of a similar locomotive for the Pennsylvania Railroad, page 267 of the July, 1907, issue, the Lake Shore engine above mentioned and the tabular comparison of locomotives published last June. An examination of these comparative tables and of the ratios given in the table below will show that while these locomotives are ex-



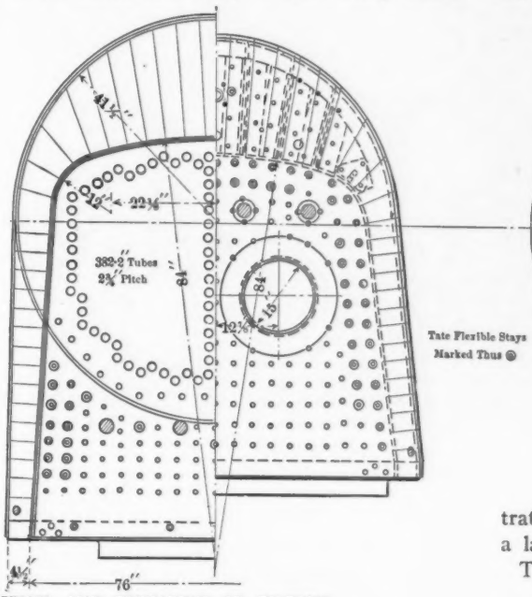


GENERAL ELEVATIONS AND SECTIONS, PACIFIC TYPE LOCOMOTIVE—NEW YORK CENTRAL LINES.



HEAVY PACIFIC TYPE PASSENGER LOCOMOTIVE—NEW YORK CENTRAL LINES.

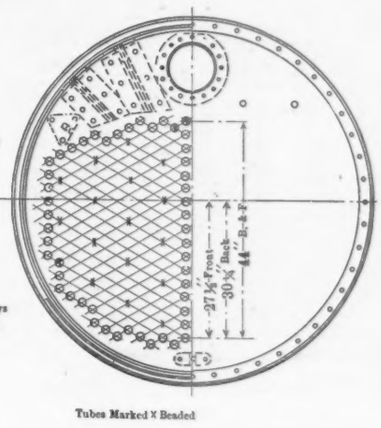
ceedingly powerful, the power is not clearly indicated by the amount of tractive effort. A theoretical tractive effort of 29,200 lbs. is seemingly small for a locomotive weighing 266,000 lbs., and actually the power of the locomotive lies in its enormous steaming capacity and in its undoubted ability to start heavy trains.



SECTION AND ELEVATION OF FIREBOX.

The ratio of adhesion of 5.84 shows that there will be no slipping troubles in starting the heavy modern passenger train of 10 to 15 cars even at stations located on curves. The B. D. ratio of 550 is considerably below the average figure for Pacific type locomotives, but is one which has been approached in all of the later designs of passenger locomotives on the New York Central Lines and shows that they certainly will not be deficient in steaming capacity.

The general construction is shown in the illustrations, as is also the general design of the very large boilers. The Walschaert valve gear is, of course, used, the design being very similar to that applied to the Lake Shore engines, the only noticeable difference being in connecting the reach rod to an upwardly extending arm on the reverse shaft, thus making the eccentric crank pin follow the main pin instead of leading it. The other important features of construction are clearly shown in the illustrations. Some of the more interesting details will be shown in a later issue.



SECTION THROUGH FRONT END.

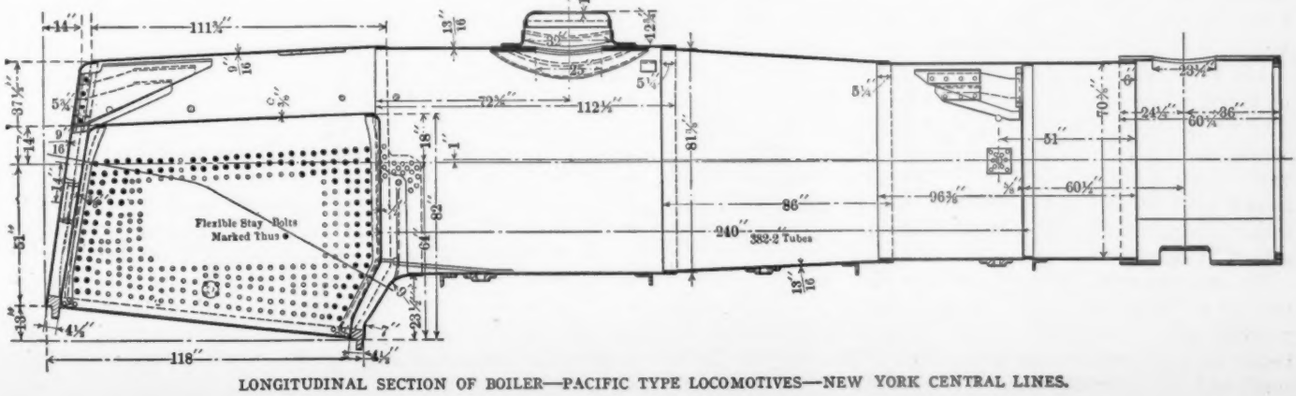
The general dimensions, weights, and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. coal
Tractive effort	29,200 lbs.
Weight in working order	266,000 lbs.
Weight on drivers	171,500 lbs.
Weight of engine and tender in working order	430,000 lbs.
Wheel base, driving	14 ft.
Wheel base, total	36 ft. 6 in.
Wheel base, engine and tender	67 ft. 11 in.

RATIOS.

Weight on drivers ÷ tractive effort	5.84
Total weight ÷ tractive effort	9.11
Tractive effort x diam. drivers ÷ heating surface	550.00
Total heating surface ÷ grate area	74.50
Firebox heating surface ÷ total heating surface, per cent	5.35
Weight on drivers ÷ total heating surface	40.70
Total weight ÷ total heating surface	63.10



LONGITUDINAL SECTION OF BOILER—PACIFIC TYPE LOCOMOTIVES—NEW YORK CENTRAL LINES.

Volume both cylinders, cu. ft.	12.32
Total heating surface ÷ vol. cylinders	341.00
Grate area ÷ vol. cylinders	4.58

CYINDERS.

Kind	Simple
Diameter and stroke	22 x 28 in.

VALVES.

Kind	Piston
Diameter	14 in.
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	⅛ in.
Lead, constant	¼ in.

WHEELS.

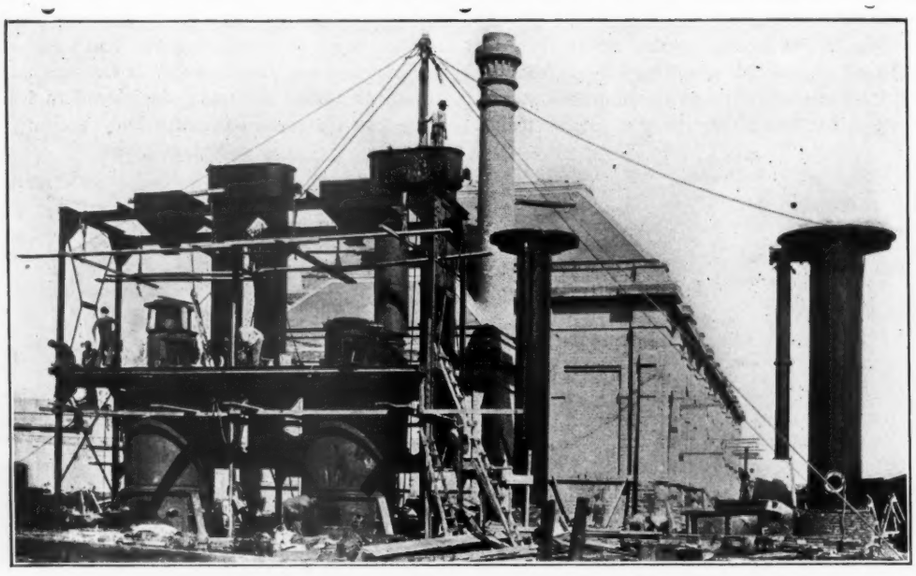
Driving, diameter over tires	79 in.
Driving, thickness of tires	3½ in.
Driving journals, diameter and length	10½ x 12 in.
Engine truck wheels, diameter	36 in.
Engine truck journals	6½ x 12 in.
Trailing truck wheels, diameter	50¼ in.
Trailing truck journals	8 x 14 in.

BOILER.

Style	Conical
Working pressure	200 lbs.
Outside diameter of first ring	72 in.
Firebox, length and width	108⅛ x 75¼ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	4½ in.
Tubes, number and outside diameter	382—2 in.
Tubes, length	20 ft.
Heating surface, tubes	3981.6 sq. ft.
Heating surface, firebox	228.3 sq. ft.
Heating surface, total	4209.9 sq. ft.
Grate area	56.5 sq. ft.
Smokestack, diameter	20 in.
Smokestack, height above rail	14 ft. 7⅜ in.

TENDER.

Tank	Water Bottom
Frame	13 in. channels
Wheels, diameter	36 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	8,000 gals.
Coal capacity	14 tons



GAS PRODUCERS IN COURSE OF ERECTION—LINIERS POWER HOUSE, BUENOS AYRES WESTERN RY.

PRODUCER GAS POWER FOR RAILWAY SHOPS.

Owing to the extremely high cost of coal in the Argentine Republic it is necessary, in considering the design of power houses of any size, to give the feature of fuel economy a most careful study. About two years ago two of the largest railway systems in that country found it desirable to build new power plants, one in connection with a complete and modern repair plant and the other for lighting and power on docks and yards as well as for the shops. Both of these companies decided to drive their generators by gas engines, working on producer gas obtained from bituminous slack, which could be purchased at a cost of $5.50 gold a ton. A thorough canvass of the subject indicated that a lower cost per k.w. hour could be obtained in this way than in any other, outside of water power, which was not available. Two years' operation of these plants have shown the soundness of the decision, and, in spite of the handicap of expensive fuel, these plants are producing current at a cost which compares very favorably with the best railway plants in this country.

The plant of the Buenos Ayres Western Railway forms part of a new locomotive and car repair plant at Liniers. This railway was the first in the Argentine Republic, being inaugurated in 1857 with a line 6¼ miles long, operated by one locomotive and four cars. In 1907 it had a line 1,160 miles in length, owned 228 locomotives, 209 passenger coaches and 5,562 freight cars. The gauge, like most of the railways in that country, is 5 ft. 6 in.

The new shops are situated about nine miles from the center of the city of Buenos Ayres and occupy a plot of ground of about 57 acres area. The plant includes coach and car building and repair shops, locomotive erecting shop, boiler, machine, blacksmith and wheel turning shops, iron and brass foundries, copper, tinsmith and painting departments, saw mill and buildings for the construction and repair of steel frame cars, besides extensive buildings for the storage of rough and finished material, storehouses, office building, power plant, etc. The locomotive section of the plant is equipped for the erection and maintenance of locomotives, but not for building, since all locomotives are ordered from either England or the United States and can be imported free of duty. Since none of the raw materials entering into locomotive construction are produced in this country it is not considered economical to maintain a plant for building locomotives.

The machinery throughout the works is electrically driven from a 440-volt, three-phase distributing system. The power is furnished by a central power station, which in addition to supplying energy for power and light also furnishes compressed air for operating pneumatic tools, hoists, air lifts in deep artesian wells and pumps for supplying all of the water used throughout the works.

The contractors for the complete electrical, gas engine and producer plant were the British Westinghouse Electric & Mfg. Co., Ltd. Most of the gas-engine equipment was manufactured by the Westinghouse Machine Co., of East Pittsburg.

The work of erection of the plant was started on December 1, 1904, by the erection of the engines and gas producer plant. All of the buildings are constructed of native hand-made brick and have saw-tooth roofs. Where possible the roofs are designed to get the southern light, but in some cases it was necessary to have the windows face the east. The works are divided by a wide central avenue running north and south. The west side is devoted to the woodworking department, coach and car building, storehouses, etc., and the east side is given up to a metal working department, locomotive erecting and repair shops, waterworks and power plant.

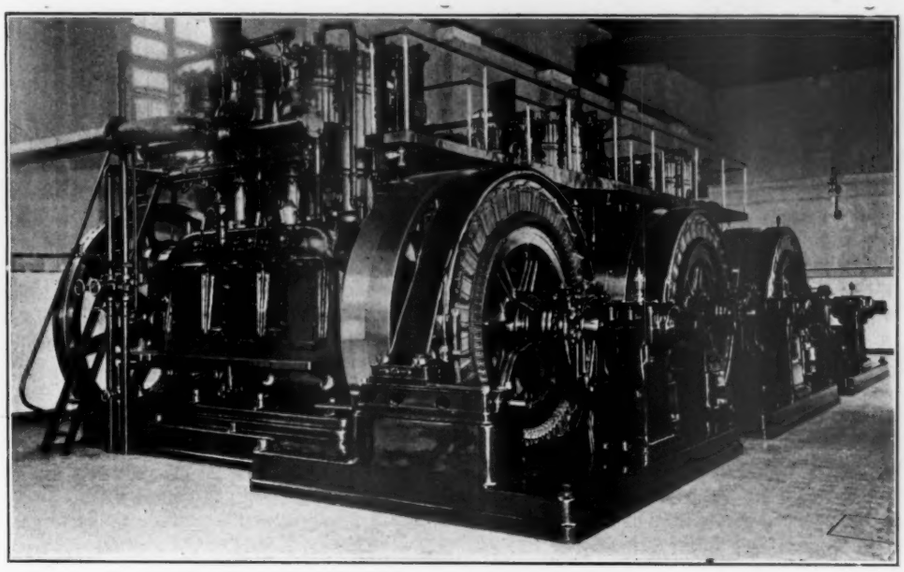
The woodworking department includes a general storehouse measuring 112 x 275 ft., having a charging and discharging platform provided with an electric walking crane of 3 tons capacity. The car building and repair shop is 230 x 223 ft. and has ten tracks passing through it. These continue outside of the building for some distance at the west end, forming a large repair yard. On the opposite side of the building the tracks extend only a short distance to a motor driven transfer table, which serves this group of buildings as well as the saw mill and passenger car building department adjoining it. This table is 70 ft. long and has a carrying capacity of 45 tons. It runs on seven lines of rails set slightly lower than the crossing tracks, thus eliminating the usual transfer table pit and permitting easy communication between the woodworking and metal working departments. The table is driven through gearing by a 10 h.p. induction motor, obtaining its current from overhead trolley wires. The saw mill, carpenter shop and coach building shop are grouped together in one building measuring 334 x 223 ft., each shop being separated by interior division walls. In the saw mill the machines are quite largely motor driven with most of the motors placed in concrete pits below the floor. The motor equipment in this shop comprises 23 motors aggregating 307 h.p., the largest motor being 60 h.p. In the carpenter, or cabinet making shop, are three electric tank heaters for glue pots.

The departments on the west side of the works are, with the exception of the painting and varnishing departments and the power house, grouped into one large building measuring 550 x 275 ft. This is divided by interior division walls into the erecting shop 126 x 300 ft.; machine shop, 140 x 126 ft.; foundry, 126 x 123 ft.; blacksmith shop, 126 x 110 ft., with an L of 63 x 60 ft.; boiler shop, 49 x 146 ft.; wheel shop, truck shop, tinsmith shop, etc. The machinery in these different shops is very largely driven on the group system from short sections of line shaft belted to motors. Overhead traveling cranes are extensively used and are supplemented by air hoists and trolleys wherever needed. The blast for the blacksmith shop and foundry is obtained from an electrically driven fan, as is also the exhaust for the Buffalo down-draft forges. The erecting shop, the interior of which is shown in one of the illustrations, has a capacity for 36 locomotives and is served by four 30-ton electric cranes, two in each bay. These cranes are of a sufficient height to enable one locomotive to be lifted and carried over another. The tracks are arranged on the longitudinal principle. The boiler and machine shops have a complete modern equipment suited to the size of the erecting shop.

The painting and varnishing department is in a separate building which measures 126 x 223 ft., equipped with seven tracks. Since the atmospheric conditions in this country are for the greater part of the time unfavorable for the drying of paints and varnishes a complete plant for artificial ventilation has been installed in this building. The heated fresh air is introduced through an extensive system of galvanized pipes to all parts of the building, the outlet being near the roof. The foul air is removed from near the floor level by numerous flues passing up through the roof.

The water supply is obtained from artesian wells about 160 ft. deep, the water being forced up by air pressure into a cistern at the surface. From this cistern it is pumped to elevated tanks. These tanks have a combined capacity of 110,000 gallons at an elevation of 60 ft. There are two separate water stations, one of which has four pumping units, all electrically driven, and the other two pumps, one being electrically driven and the other a duplex steam pump. There are 78 fire hydrants located throughout the works.

Power Plant.—The power plant is situated at the extreme eastern end of the works and includes a power house of brick construction with a mansard roof which measures 200 x 42 ft. This building is divided by partition walls 14 ft. high into three large rooms, there being one department for the gas plant machinery, another for the engine and dynamo equipment and the third for the air compressors, in addition to offices, work shop and storeroom.



GAS ENGINES AND GENERATORS, LINIERS POWER HOUSE.

The gas producer plant is located outside of the power house and is not under cover. It consists of two water sealed Mond bituminous producers 6 ft. inside diameter, each capable of gasifying ten tons of coal in 24 hours, together with the accompanying purifying and cleansing apparatus. These producers, which are shown in course of erection in one of the illustrations, are placed close together and surrounded by columns which support the staging carrying the coal bunkers, coal elevator and conveyor, superheater tower and charging platform. The superheater towers or regenerators are placed at the back of the producers, on the side toward the building, and rise to a height of 40 ft. above the ground level. The coal is brought in in barrows and dumped into a hopper at the foot of an elevator where it passes through a feeding device to the elevator buckets and is raised, discharging into a conveyor, which in turn discharges it into either bunker, as desired. From this point it moves altogether by gravity. The gas leaving the top of the producer passes first through the superheater tower, then through washers, gas tower, gasometer, washing fans, sawdust scrubber and condenser in each of which impurities are removed and by the time it reaches the engine it is a clean colorless gas. The process of forming the gas is, briefly, as follows:

A Korting blower of the injector type, the operation of which is controlled automatically by the gasometer, provides a blast of

INTERIOR OF ERECTING SHOP, LINIERS SHOPS—BUENOS AYRES WESTERN RY.

air which passes first through an air heating tower in which there is a stream of hot water passing and there takes up a certain amount of heat and moisture. This mixture is then conveyed along the mains to the superheaters, which consist of two tubes forming an annular space through which the air and steam passes. The hot gases from the producer pass down through the inner tube in the opposite direction from the air and steam and a large amount of its heat is transferred to them. From this the hot air and steam pass through a similar annular space around the producer and downward below the fire bars. The gas after passing through the superheater goes to a washer having two dashers revolving at a good speed, which throw the water contained in the washer into a fine spray through which the gas passes, thereby being cleaned and at the same time giving up a large amount of heat. It is then taken to the gas cooling tower, consisting of a cylindrical vessel packed with small earthenware tubes. The water which heats the air in the air tower obtains its heat by being pumped through this gas cooling tower and thus simply transforms the heat from the gas to the air, operating continually. On leaving the cooling tower the gas is taken to a gasometer and thence to two fans which by their centrifugal force throw out any particles of tar and dust, etc., being aided by the injection of a stream of cold water into the interior of the fan. From this point it passes to the sawdust scrubbers, and is ready for use in the gas engines.

The pumps for circulating the water and the blowers for supplying the blast are driven by steam. The gas washing fans are belted to the line shaft, which supplies power for the coal elevator. This shaft is driven by a Marshall upright steam engine and from it is also belted a small sparking dynamo to start the main engines. After the main engines are started, however, the shaft is driven by a 10 h.p. electric motor. Another Marshall upright steam engine is provided which is belted to a direct-current generator, furnishing electric light for sections of the plant, when the main power station is not working, and also supplies power for an electric pump.

The gas engines, of which there are four, are of the Westinghouse three-cylinder type, direct connected to Westinghouse three-phase alternators. These engines work on the four-cycle principle, three being of 250 brake h.p. capacity, with cylinders 19 x 22, coupled to 150 kw. generators. These operate at 200 r.p.m. The fourth unit is a 125 h.p. engine with 15 x 14 in. cylinders coupled to a 75 kw. generator, operating at 272 r.p.m. The exciting current is furnished by a motor generating set consisting of a 60 h.p. induction motor coupled to a 40 kw. 125-volt dynamo. For starting, exciting current is taken from the steam-driven lighting set.

There are a total of 93 motors aggregating 1071½ h.p. in the whole plant. Practically all of these are induction motors.

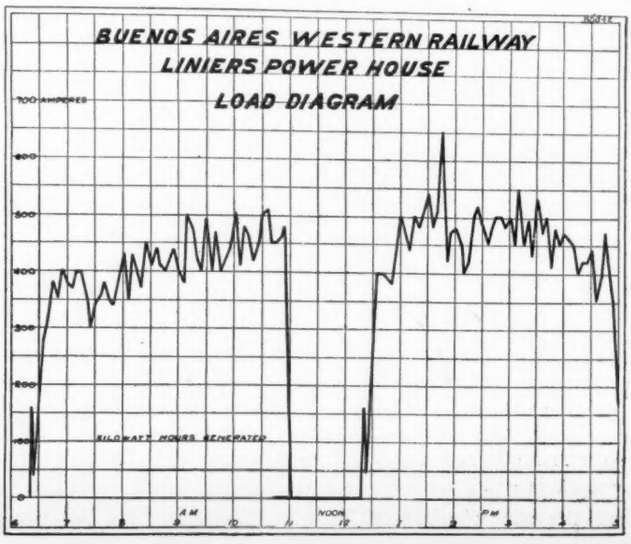
The air compressing plant consists of two Ingersoll-Sargeant duplex compound compressors belted to 80 h.p. induction motors; each compressor has a capacity of 350 cu. ft. of free air per minute. They furnish 90 lbs. pressure.

There are also two gas engine driven air compressors for supplying a pressure in the storage tanks for starting the large engines. There are four of these tanks, all approximately 40 cu. ft. capacity, which have a pressure of 190 lbs.

The power distribution is all from three-phase circuits at 440 volts, 50 cycles. One of the illustrations shows the load curves on the station for 24 hours and give a very good idea of the variation which occurs.

GREAT SOUTHERN RAILWAY PLANT.

The producer gas plant for the power station of the Buenos Ayres Great Southern Railway, which in addition to furnishing power for the repair shops also furnishes light and power for the docks and freight and passenger stations along the line for a distance of about 12½ miles, is somewhat larger but of the same type as that for the Western Railway above described. There are in this station four Mond producers, 5 ft. inside diameter,



and the coal is dumped from the cars directly into the elevator boot. In the power house there are six Westinghouse vertical, three cylinder, single acting gas engines, each with a nominal output of 250 h.p., direct connected to Westinghouse three-phase 50-cycle, 440-volt alternators, of 150 kw. each. From the power plant the current is distributed by overhead transmission lines to the repair shops at 440 volts for power and 110 volts for lighting. Westinghouse three-phase, type C, induction motors are used throughout the plant. The power for use at more distant points is stepped up from 440 volts to 6600 volts. It is transmitted over a high tension system of underground wires to the several sub-stations, where it is again stepped down. At one of the substations there are two 400 kw. Westinghouse rotary converters for supplying direct current at 550 volts for the cranes, capstans, grain elevators, etc., along the docks.

This plant was put into service March 14, 1904, and during the first six months there were three stoppages, the whole amounting to nine minutes, the delays being principally caused by an accumulation of water in the gas mains. From that time to the present, however, there has been no delay of any kind.

The number of men employed at present in working the plant for 24 hours a day, with five engines running from 6.40 A. M. to 4.15 P. M., two from 4.15 to 12.00 P. M. and two from 12.00 to 6.40 A. M. is as follows: Seven producer men, three stokers, two laborers, three engineers, two oilers, three switchboard attendants, one fitter and two boys. The men work in eight-hour shifts. The monthly pay-roll for the 23 hands amounts to $1,113 gold. The engine room staff, it will be seen, is not more than would be required for a steam driven plant, but the gas plant necessitates nearly twice as many men as a steam plant of the same capacity, but it must be taken into considertion that a plant 50 per cent. larger could be operated by the same staff.

The average coal consumption during the past six months, including all losses from the time it leaves the ship, amounted to 3.1 lbs. per kw. hour, but as low as 2.1 lbs. per kw. hour is constantly reached with the day load.

The working cost per kw. hour for a period of six months with coal taken at $5.50 gold per ton is shown in the following table:

	Day.	Night.	Average.
Fuel	$0.0052	$0.0088	$0.0076
Oil, waste, water and stores	0.0010	0.0020	0.0013
Repairs and renewals	0.0012	.....	0.0012
Wages	0.0048	0.0098	0.0070
Total	$0.0122	$0.0206	$0.0171

VESSELS BUILT IN 1907.—The output of the world's shipyards for the year 1907 was 1,930 vessels of over 100 tons displacement, with an aggregate of 3,099,299 tons. The tonnage of the vessels built in the United States amounted to 474,675 tons, which is 33,400 tons greater than the output for the previous year. Of the total tonnage of the vessels built in this country, considerably more than half was constructed for the Great Lakes.—*Machinery.*

VALUE OF TECHNICAL JOURNALS.—It is a curious and interesting commentary on modern scientific and industrial development that book making cannot keep pace with it. The surgeon can learn the groundwork of his profession from recognized textbooks, but to keep abreast of the best current practice he must either see that practice, or hear it described, or read of it in the technical publications devoted to that alone; the lawyer can pass his bar examinations on the basis of his theoretic instruction at the law school, but to win cases he must read cases, as fast as decisions are handed down. The same thing has always been true of the work of the civil and the mechanical engineer; certain standard books on bridge design and on locomotive design have collected together a great group of cardinal principles derived from two generations of practical experience, but no text-book has ever yet or will ever be able to contain a full record of progress as it is illustrated by the best current practice—a record corresponding to the cases which the lawyer studies and also to the cases of a different kind which the surgeon studies. As rule-of-thumb methods in engineering work have more and more given way to scientific methods it has been more and more necessary for the engineer to know just what was being done simultaneously in all parts of the world.—*The Railroad Gazette.*

FOREIGN CAR REPAIR BILLS.

BY J. E. EPLER.*

The foreign car repair bill is an item in the income account of a railroad that has not received the attention it deserves. The object of this article is to present an improvement on the old method of instructing repairmen in making M.C.B. repair stubs and to prevent bills from being returned to the maker by the accounting office.

The method proposed should bring about more accurate results and a minimum number of incorrect bills. It is a very easy matter to find fault with a bill after it is made, especially if the fault-finder is seated at a desk surrounded with books on rulings, exceptions and decisions, but it is an altogether different proposition for the man in the repair yard, who is making out the original bill, and knows little more than his standard book of rules tells him.

This man is usually pressed for time; quite frequently has had to place his own interpretation on a thousand and one rulings as to how bills should be made, and quite often has never read the rules. In his rather crude manner he makes the bill, stating merely that he has applied a bolt: "Bolts are bolts anyway and what is the difference?" Sometimes he is hurried and hopes the bill may go through, but does not care if it is returned to him for correction later. He will then probably have more time to patch it up. Perhaps he is painstaking and thinks he should give information that proves to be unnecessary. All this tends to increase the work in the auditor's office and hold up bills for correction, sometimes resulting in a loss of the amount billable.

The plan suggested is a simple one. Merely a little pamphlet to be enclosed as an appendix to the regular M.C.B. book. Each article in a car is treated separately. Articles are arranged in alphabetical order and all information on the bill is indicated opposite the article. The following samples will show clearly the method:

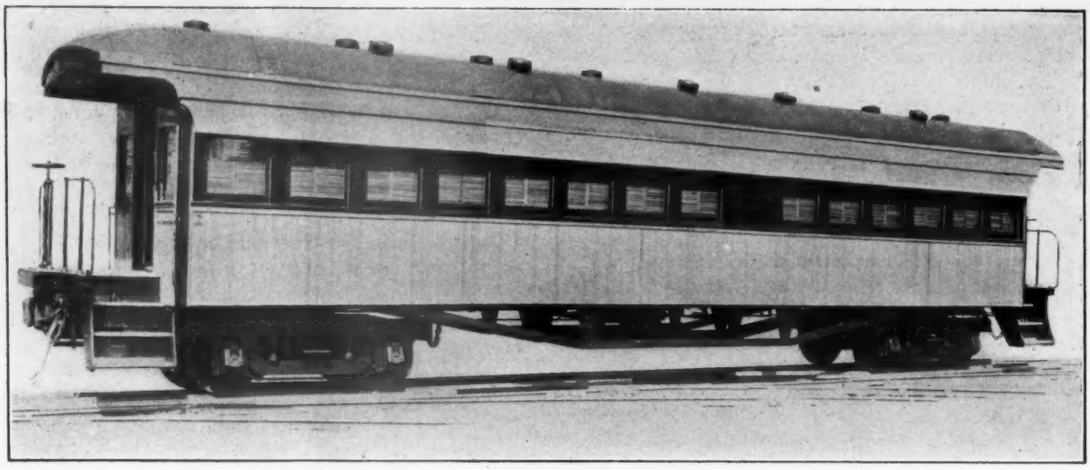
Bolts
- **Carry-iron**
  - Number of bolts applied
  - Size of bolts applied
  - End of car
  - Cause of renewal

Beam
- **Brake**
  - Oak
    - Number of beams applied
    - Kind of material
    - Size of material
    - Number and size of bolts applied
    - Solid or trussed beams
    - Amount of paint used
    - End of car
    - Cause of renewal
  - Metal
    - Number of beams applied
    - New or second-hand
    - State name of beam applied
    - Renewed or repaired
    - State whether beam is missing or broken
    - State kind of beam removed
    - Specify part broken
    - End of car
    - Cause of renewal

When making the bill the repairman fills in all information as indicated and cannot very well go astray.

MEETING OF THE A. S. M. E.—The semi-annual meeting of The American Society of Mechanical Engineers will be held in Detroit, Michigan, June 23-26. Among the papers to be presented at this session are "A Method of Cleaning Gas Conduits," by W. D. Mount; "A Method of Checking Conical Pistons for Stress," by Prof. George H. Shepard; "Clutches" with special reference to automobile clutches, by H. Souther; "Horse-Power, Friction Losses, and Efficiencies of Gas and Oil Engines," by Prof. L. S. Marks; "Some Pitot Tube Studies," by Prof. W. D. Gregory; "The Thermal Properties of Superheated Steam," by Prof. R. C. H. Heck; "A Journal Friction Measuring Machine," by Henry Hess; "A By-Product Coke Oven," by W. H. Blauvelt; "Tests of Some High Speed Steam Engines," by F. W. Dean. There will be a symposium upon machinery for conveying materials, with papers by several authorities. The Society for the Promotion of Engineering Education and the Society of Automobile Engineers will also hold their annual meeting in Detroit at this time, which will enable members of each society to participate in the sessions of the others.

* Bonus Expert, Santa Fe.



FIRST-CLASS PASSENGER CAR—PHILIPPINE RAILWAY COMPANY.

PASSENGER CARS FOR THE PHILIPPINE RAILWAY.

About two years ago the Philippine Railway Company was granted a perpetual concession for building, equipping and operating between 300 and 400 miles, about equally divided between the islands of Cebu, Panay and Negros. The map shows the proposed routes, the dotted lines indicating mileage not finally located. On June 14, 1906, a party of fifty American engineers, organized by J. G. White & Co., constructing engineers for the railroad, landed in the Philippines. Previous to this time a thorough study of the resources and topography of the island had been made and tentative routes had been mapped out. The engineers divided into several parties and surveys on all three of the islands were pushed as rapidly as possible, so that by November nearly all the main surveys were completed and ground was broken on Cebu.

According to the concessionary contract sections of not less than twenty miles are to be put in operation as completed. Two sections are already in operation upon the island of Cebu and one on Panay. It is expected that the third section on Cebu will be placed in operation about May and the second section on Panay about August of this year. It was feared that it would be necessary to import Chinese labor for building these roads, but the contractors found that by paying a good wage, and furnishing the workmen with a scientifically proportioned diet of good nourishing food, splendid results could be obtained and a first-class lot of workmen are rapidly being developed.

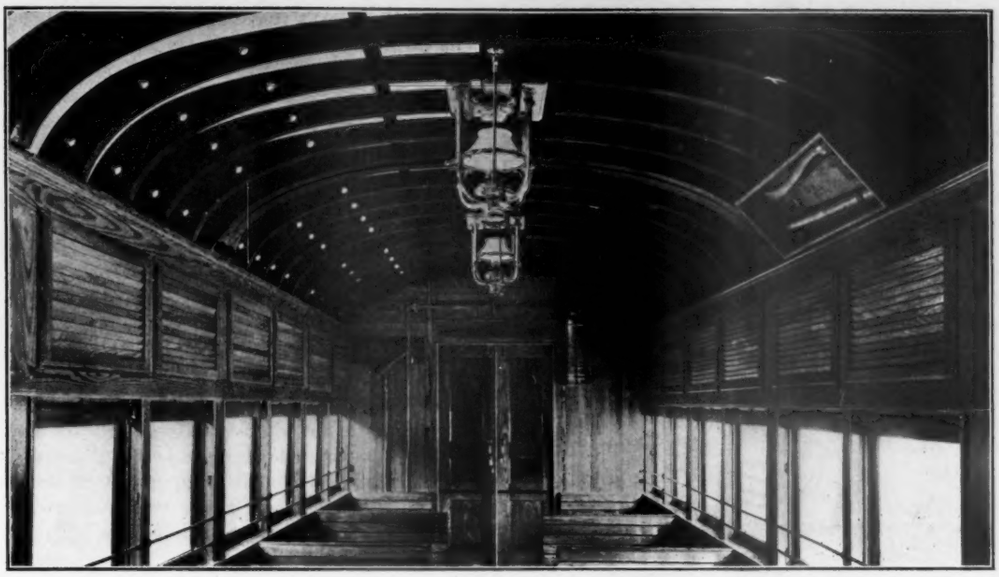
The original concession provided for a 3-foot 6-in. gage; other questions of construction, equipment and operation have been left to the directors of the company, the Technical Board, and the Philippine Commission. For the construction work four 50-ton mogul locomotives were ordered; also 3 light construction engines, fifty 40-ton flat cars and fifty Roger convertible ballast cars. The mogul locomotives have 17 x 24 in. cylinders, 50 inch drivers and a tractive effort of 21,000 lbs. High carbon native lignite coal is used as fuel; diamond stacks and spark arrestors are used to prevent the escape of sparks.

Recently six mogul locomotives were ordered; also four combination parlor and first-class cars, four combination baggage and second-class cars, fifteen second-class cars, forty 10-ton and forty 20-ton box cars. These have been completed and are in transit; meanwhile but one train a day is operated in each direction, accommodations for passengers being provided by roofing over and building seats on the flat cars.

The cars were designed by G. R. Henderson, who acts in the dual capacity of consulting engineer for the railroad company and for the Philippine Commission. The passenger cars were built at the Wilmington, Del., plant of the American Car & Foundry Company. The designer was confronted with several peculiar problems. The construction must be as simple and substantial as possible, and such that what few repairs may be necessary can be made by unskilled labor. The cars must be suitable for a tropical climate and the design must be such that after being erected at the works they could be knocked down into convenient sections for shipment. The details of the different types of the passenger cars, as well as of the freight equipment, have been made interchangeable, as far as possible. The general dimensions of the combination parlor and first-class passenger cars are as follows:

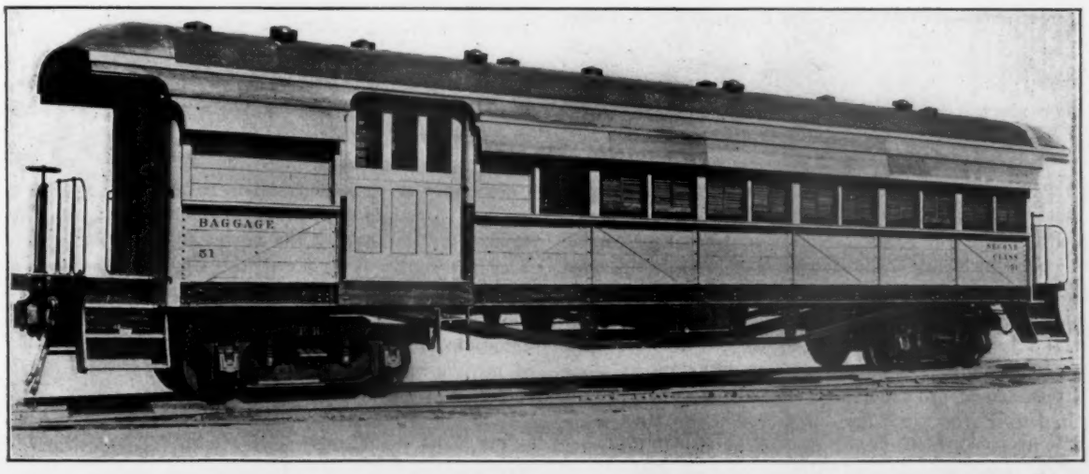
Length over body of car	43 ft. 1½ in.
Width over sun shades	9 ft. 6 in.
Inside length of car	42 ft. 3½ in.
Inside width of car	7 ft. 9¼ in.
Height from side sill to plate	6 ft. 9 in.
Length over underframing	43 ft.
Width over underframing	8 ft. 4½ in.
Distance between truck centers	32 ft. 6 in.
Height from rail to center of coupler	2 ft. 10 in.
Height from rail to top of platform	4 ft. 2 in.

The dimensions of the second-class passenger and the combi-



INTERIOR OF SECOND-CLASS PASSENGER CAR, WITH THE ROOF ONLY PARTIALLY FINISHED, SHOWING THE HOLES THROUGH THE CARLINES FOR CIRCULATION OF AIR IN THE ROOF.

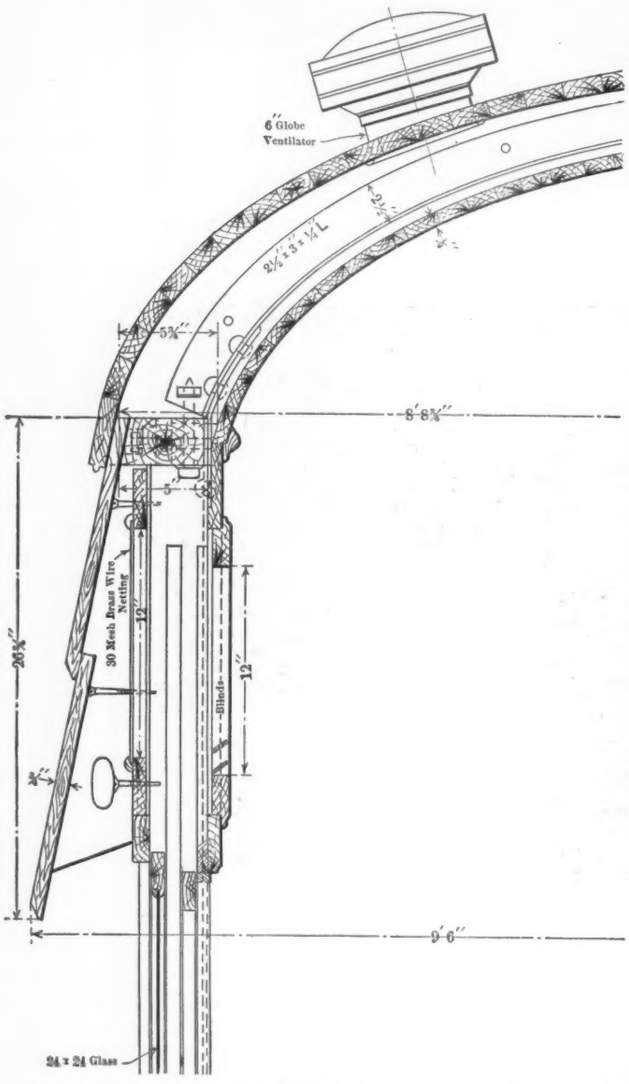
INTERIOR OF FIRST-CLASS PASSENGER CAR. THE ROOF IS SIMILAR TO THAT FOR THE SECOND-CLASS PASSENGER CAR, EXCEPT THAT THE INSIDE CONTOUR IS CHANGED TO GIVE A CLEAR-STORY EFFECT.



COMBINATION BAGGAGE AND SECOND-CLASS PASSENGER CAR—PHILIPPINE RAILWAY COMPANY.

nation baggage and second-class passenger cars are the same except that the inside length of these cars is 4 in. less and the inside width 1 in. less. The underframes of the different types of passenger equipment are interchangeable. They consist of standard shapes of open hearth steel, the center sills being 10 in. channels, weighing 15 lbs. per foot. These have a top cover plate extending from the end plates to the center of the car and are latticed underneath. The sills are spliced in the middle, so that the underframe can be shipped in two sections. The underframe is trussed by four steel angles, 4 x 3 x ⅜ in. with queen posts built of ¼ in. plates and 4½ x 2½ in. T's.

The bolsters have ⅜ x 18 in. top and ⅝ x 12½ in. bottom plates with a ⅜ in. web and steel connecting angles. The center sills at the bolster are securely tied by two channel sections connected to the sills by angles. The end sills are built up of Z-bars,



PARTIAL SECTION THROUGH THE ROOF AND THE SIDE ABOVE THE WINDOWS OF THE SECOND-CLASS PASSENGER CARS.

angles and plates. The steel platforms are of special design furnished by the Standard Coupler Company. The couplers have a side movement of 5 in. in either direction and are kept central by flat springs on each side. The uncoupling lever is operated from the ground by a 3/16 in. chain on the left side.

Yellow pine sills for supporting the floor are securely bolted to the side and center sills and also to cross channels. The flooring is of yellow pine 1¾ in. thick. The corner posts, door posts and lintels, are of ash; the side and end plates are of yellow pine bolted to T-iron posts and plates. The sun shades are of teak and will be furnished and applied in the Philippines. The sides of the cars were shipped in three sections each.

The roof is partly supported by 4½ x 2½ in., 8 lb. T's attached to the frame by gusset plates and braced by ¼ x 2½ in. iron straps, which run diagonally and are bolted to the siding. The carlines are of flat iron, 1½ x 2 in., except where the different sections of the roof are joined, in which case they are of angle iron. The roof is covered with yellow pine, 13/16 in. thick, and ceiled with yellow pine ¾ in. thick, leaving a considerable air space between, as shown on the drawing. The central ventilators extend through the roof and ceiling, but the side ventilators extend through the roof only. Reference to the detail drawing will show that the air may be drawn up underneath the sun shade, through the netting and the holes in the side plate and out through the side ventilators, or it may pass up underneath the sun shade, through the wire netting and the blinds into the car and out through the central ventilators. The carlines have holes in them, as shown on the photo of the interior of the second-class car, to assist in the circulation of the air in the roof.

Some idea of the interior finish of the cars may be gained from the accompanying photographs. The outside sheathing on the parlor cars is teak and is to be applied at the Philippines. The second-class cars do not differ greatly from the first-class cars except as regards the finish, no outside sheathing being applied to the second-class cars, and the interior finish being more simple and plain. The cars complete weight about 42,000 lbs.

The trucks are equipped with 4¼ x 8 in. journals and 30 in. wheels weighing 550 lbs. each. The side frames are steel angles, 6 x 4 x ½ in., connected by ¼ in. gusset plates with the 4 x 3 x ⅜ in. end angles. Eight-inch steel I-beams are used in both the transoms and bolsters. The spring plank is built up of angles and plates.

THE AUTOMOBILE INDUSTRY.—Statistics recently compiled by the Association of Licensed Automobile Manufacturers show that the total value of American made automobiles for 1907 was $105,669,572. This represents 52,302 cars manufactured during the year. Of these, all but 5,000 were gasoline vehicles, the smaller number being divided between steam and electric machines. In 1904 the value of the automobile output of the United States factories was $26,645,064, and a steady increase has been noticeable every year since. It is estimated that 58,000 employees were engaged last year in the various factories, while the capital employed was more than $94,000,000. As in many other manufacturing products, there is an indirect investment, which is closely allied to vehicle manufacture. This includes such products as tires, rims, lamps, speedometers, drop forgings, etc. Close estimation shows that there are 29,000 men employed in this indirect manufacture, with a total capital of $36,700,000. Unlike many other manufactured products, the sales end of the automobile industry is exceedingly expensive. At the close of the year 1907 there were 2151 sales and garage establishments employing 21,500 persons, with a capital of $57,500,000. Not including the manufacture of motor cycles or the sale of supplies and accessories, the total estimation is: Value of product sold, $105,669,572; total capital employed, $171,448,769; number of employees involved, 108,500.

DON'T DEPEND ALTOGETHER ON ENGINEMEN'S REPORTS.—What is needed most to make pooling a success is a determination on the part of the mechanical officers, from the superintendent of motive power down through the list in their order, to take care of the power regardless of whether the enginemen help any or not. Depending on such help and not getting it, is a poor excuse for not having the power in good serviceable condition. The better plan is to do all the work reported and all that appears necessary even though it is not reported. Every man in the official organization of a shop or round house should be ambitious and not a shirk. There is no room for the latter class of men in an up-to-date organization.—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

Trade of the United States with its American neighbors in 1907 amounted to nearly $1,000,000,000, against a little more than a third as much a decade ago.

POWER REQUIREMENTS OF RAILROAD SHOP TOOLS.*

By L. R. POMEROY.

Generally speaking, the generator capacity for railroad repair shops is equal to approximately 15 kw. per locomotive pit, or space in erecting shops occupied by one locomotive. This includes the requirements for tools, cranes, heating, blower and exhaust fans: *i.e.*, provides for all power required except that needed for lighting.

The tools alone require about 9 or 10 kw. per pit; the heating, and the blower and exhaust fans demand 5 kw. per pit, while 3 kw. per pit will care for the ordinary shop and adjacent yard lighting. If in addition to shop requirements, power is needed for lighting terminal yards, buildings, etc., an increase in generator capacity must be made to cover such demands.

The accompanying curves and tables are submitted to cover the horse power requirements of the machine tools generally found in railroad repair shops.

BOLT AND NUT MACHINERY, HELVE HAMMERS, MULTIPLE DRILLS, ETC.

	Motor h.p. required to drive
1½" single head bolt cutter	1½
Pratt & Whitney No. 4 turret bolt cutter	2
2 spindle stay bolt cutter	2
1½" Acme double head bolt cutter	2½
1½-2½ Acme nut facer	2½
6 spindle nut tapper	3
1½" triple head bolt cutter	3
¾-2½" double head bolt cutter	3
2" triple head bolt cutter	5
4 spindle stay bolt cutter	5
Bradley hammer	7½
Niles 4 spindle multiple drill	7½

PUNCHES AND SHEARS.

	Motor h.p. required to drive
No. 4, 36" throat, L. & A. punch	3
No. 9 horizontal flange punch	5
No. 2 Hillis & Jones combination punch and shear	5
Alligator shear (stock 5" x 1")	5
Lenox rotary bevel shear	7½
36" multiple tank plate punch with spacing table	7½
No. 3 Hillis & Jones combination punch and shear, 12" throat	7½
No. 2 horizontal punch 20" throat	7½
No. 3 Hillis & Jones combination punch and shear, 36" throat	10
No. 3 angle shear 5" x 1" bar	10

SAWS.

	Motor h.p. required to drive
Band saw, 36" wheel	3
Band saw, 42" wheel	5
Swing cut off saw	5
Band saw, 48" wheel	7½
Greenlee 1½ self-feed rip saw	10
Greenlee vertical automatic cut off saw	15
40"-46" saws	15
Auto. band resaw	20
Greenlee No. 6 aut. cut off saw	20
Greenlee No. 3 rip saw	20
Woods No. 4 rip saw	20
Extra heavy aut. rip saw	25

GRINDERS.

	Motor h.p. required to drive
Air cock grinder	1
No. 3 Brown & Sharp universal grinder	3
Link grinder	3
Sellers universal grinder for tools	5
Norton 18" x 96" piston rod grinder	5

MILLERS.

	Motor h.p. required to drive
Vertical miller, Becker-Brainard No. 2	1
Valve miller No. 2	2
Universal miller No. 3, Brown & Sharp	2
Universal miller No. 4, Brown & Sharp	3
Universal No. 6, Becker-Brainard	5
Niles heavy vertical	10

WOOD WORKING TOOLS.

	Motor h.p. required to drive
Fay-Egan single spindle vertical boring machine	3
Fay-Egan 3 spindle vertical boring machine	4
Fay-Egan No. 6 vertical mortiser and borer	6
Fay-Egan No. 7 tenoner or gainer	7½
" universal wood worker	7½
" 4 spindle vertical borer	7½
" 5 spindle vertical borer	10
14" inside moulder	12
Fay-Egan universal tenoner and gainer	12
" vertical tenoner	12
Greenlee aut. vertical tenoner	15
Fay-Egan No. 3 gainer, also Greenlee	15½
Greenlee Ex. Range 5 spindle borer and mortiser	15
Greenlee vertical mortiser	15
Fay-Egan auto. gainer, also comb. gainer and mortiser	20
Fay-Egan No. 8 vertical saw and gainer	20½
Vertical hollow chisel mortiser and borer	20
Fay-Egan 14½" double cyl. surfacer	20½
Heavy outside moulder	20
6 roll D. C. planer and matcher	25
Double cylinder fast flooring machine	30
Double cylinder planer and matcher	30
Fay-Egan No. 8 auto. tenoner	30½
Woods No. 27 matcher	25
4 side timber planer, heavy	60

Occasionally certain tools are selected for the purpose of performing extra heavy service, to utilize the full capacity of the new rapid cutting tool steel, as is now done in manufacturing shops. In such cases the power to drive the machine must be figured on the basis of service required, but as these cases are few and exceptional, the curves will be found to meet the majority of conditions, and the exceptions can be taken care of by the following formula:

$$\text{Horse power to drive} = F \times D \times \text{f.p.m.} \times 12 \times N \times C \qquad (1)$$

Where:—

F = feed in inches
D = depth of cut in inches
f.p.m. = feet per minute
N = number of tools cutting
C = a constant with the following values, depending on the class of material:—

Cast iron	0.35 to 0.5
Soft steel or wrought iron	0.45 to 0.7
Locomotive driving wheel tires	0.70 to 1.00
Very hard steel, such as crucible steel driving wheel tires	1.00 to 1.10

This formula is based on Prof. Flather's dynamometer tests, which check up fairly well with actual motor tests, and it is therefore submitted with confidence.

As an example of its accuracy, the aggregate horse power of 45 tests made with various tools was 247.7, while the calculated aggregate horse power by formula equalled 247.2.

* From the October, 1907, issue of the *General Electric Review*.

The extensive tests made by Dr. Nicholson of the Manchester Technical School, England, confirm the correctness of the foregoing formula, and form a very interesting contribution to the subject. A careful analysis of the results of these experiments shows the average horse power required at the motor, per pound of metal removed per minute, to be as follows:

Medium or soft steel or wrought iron	2.4 h.p.
Hard steel	2.65 h.p.
Cast iron, soft or medium	1.00 h.p.
Cast iron, hard	1.36 h.p.

Using the symbols of previous formula the horse power becomes:—

$$F \times D \times \text{f.p.m.} \times 12 \times N \times W \times K \qquad (2)\dagger$$

where W equals the weight in pounds of a cubic inch of the metal, and K is the coefficient for that metal as given above. The value of W for the different metals is as follows:—

Cast iron	0.258
Wrought iron	0.278
Steel	0.284

The following examples illustrate the more or less heavy cuts to which reference has been made; the larger powers given are exceptional, while the average requirements are far below these, and all are submitted as actual cases which have come under the writer's observation:

(a) 100 inch driving wheel lathe—(material steel driving wheel tires) 5/16" feed, 5/16" cut, at 18.5 feet per minute—two tools cutting.
Substituting in formula (1) we have:—
$5/16 \times 5/16 \times 18.5 \times 12 \times 2 \times C = 40$ h.p.
Same lathe, 3/16" feed, ¼" cut, at 16 f.p.m.—two tools cutting
$3/16 \times ¼ \times 16 \times 12 \times 2 \times C = 16$ h.p.

(b) Old 76 inch driving wheel lathe, (material driving wheel tires)
$1/16 \times 1/4 \times 16 \times 12 \times 2 \times C = 5$ h.p.

(c) Steel tired wheel lathe (material engine truck wheels)
$1/7 \times 5/16 \times 16 \times 12 \times 2 \times C = 17$ h.p.

(d) Planer (material cast iron)
5/32" × 3/8" × 10' × 12 × 0.35 (one tool cutting).....4.5 h.p.
(two tools cutting) .....9 h. p.

(e) Planer (material wrought iron engine frame)
5/32" × 1/2" × 16' × 12 × 2 × 0.5 (two tools cutting)...15 h.p.

(f) 76 inch boring mill (on cast steel driving wheel centers)
1/8" × 2/4" × 30' × 12 × 3 × 0.45 (three tools cutting)..45 h.p.
Same machine boring driving wheel tire
1/8" × 3/16" × 28' × 12 × 2 × 1 (two tools cutting)....15 h.p.

(g) 84 inch boring mill (on 62" cast iron wheel centers)
1/8" × 1/10" × 30' × 12 × 3 × 0.35 (three tools cutting) 4.7 h.p.
Same mill boring 44" steel tire
1/4" × 3/32" × 26' × 12 × 2 × 1 (two tools cutting)...14.5 h.p.

(h) The following is a special test on an extra heavy driving wheel lathe, and gives results representing unusual conditions. The operator was given a heavy bonus to develop the ultimate capacity of the machine.
Average feed 0.4625", depth 0.0423", at 12.2 f.p.m. (two tools cutting).
These figures are the averages of 37 tests, and represent a consumption of 40 h.p., while the maximum h.p. required was about 65. The machine was equipped with a 40 h.p. direct current motor with 2.1 speed variation.

† W × K in formula (2) = C in formula (1). For cast iron W × K = .258 × 1.00, or 1.36 = .258, or .35. For wrought iron W × K = .278 × 2.4 = .667. For hard steel W × K = .284 × 2.65 = .75.

The lathe in question was a "special," extra heavy, and of about double the capacity and cost of the standard driving wheel lathe of equivalent size. On average work, the same investment if expended on two lathes will turn out more work in a year than this special machine.

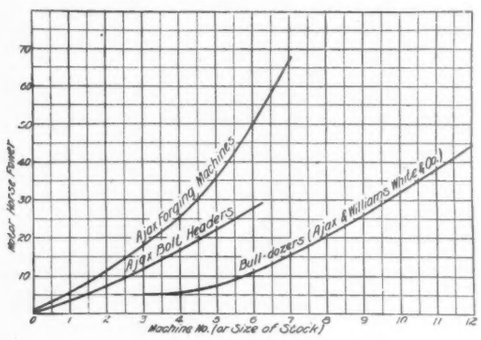
For rapid estimates, where the foregoing data is not available, the horse power required can be obtained by the following formulæ:

$$\text{(Single belt) horse power} = \frac{d \times f \times \text{r.p.m.}}{12 \times 400} \qquad (3)$$

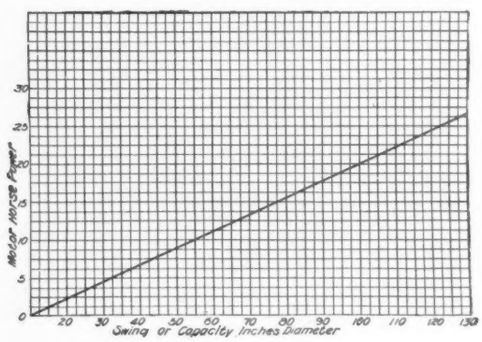
$$\text{(Double belt) horse power} = \frac{d \times f \times \text{r.p.m.}}{12 \times 400 \times 0.7} \qquad (4)$$

where:
d = diameter of smaller pulley in inches
f = face of pulley in inches
r.p.m = revolutions per minute.

These formulæ are very conservative and provide for about as much overload capacity for belts as is ordinarily assumed for motors; they also provide a liberal allowance for the influence of centrifugal force, and for the diminishing arc of contact on the pulley, when it is driven from a larger one. They are espe-


Motor Horse Power
Ajax Forging Machines
Ajax Bolt Headers
Bull-dozers (Ajax & Williams White & Co.)
Machine No. (or Size of Stock)

FORGING AND BOLT HEADING MACHINES.



BORING MILL—ONE TOOL CUTTING 20 FT. PER MIN.

cially useful in figuring the power required for wood working machines and were arrived at largely from experience with such apparatus.

Another formula, adapted from Ruleaux, giving somewhat higher values, is preferred by some, as it considers the thickness of the belt. In this case the allowance for centrifugal force and for the arc of contact, being less than 180 degrees, is taken care of in the selection of values for the constant C:

$$\text{Horse power} = t \times w \times \text{f.p.m.} \times C, \qquad (5)$$

or if the r.p.m. and not the f.p.m. is known:

$$\text{horse power} = \frac{t \times w \times d \times \text{r.p.m.} \times C}{4}$$

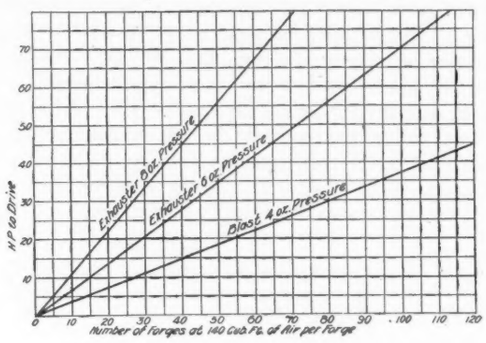
where:
t = thickness of belt in inches
w = width of belt in inches
d = diameter of pulley in inches
C = a constant, of following values:

Leather belt	0.0062 to 0.0098
Cotton belt	0.0036 to 0.0068
Rubber belt	0.0050 to 0.0082

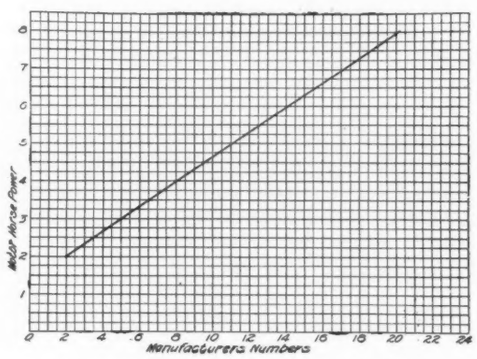
The tool builders do not always discriminate between the requirements of manufacturing plants and those of railroad repair shops, and for this reason motors are often recommended that are larger than necessary. For example: the *finished* product of the axle departments of such concerns as the United States Steel, Midvale, Bethlehem, and Cambria Companies, becomes the *raw* material for railroad shops. In the former shops the forging is turned out from the hammer without much regard to finished dimensions, as it is much cheaper to rough out to size on special rapid reduction lathes than to attempt to reduce to size under the hammer.

For such machining high power is required, but for the same lathes in railroad shops, where the work performed is mainly finishing cuts on journals and wheel seats, a smaller and cheaper motor may be selected.

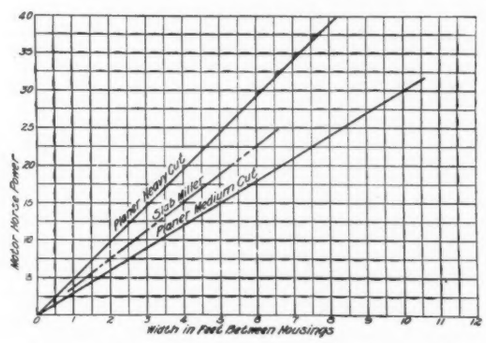
The Bement-Niles lathe which was furnished the Howard Axle Works may be given as an example of extreme requirements, such as mentioned. The capacity of this machine is two


H.P. to Drive
Exhauster 8 oz. Pressure
Exhauster 6 oz. Pressure
Blast 4 oz. Pressure
Number of Forges at 140 Cub. Ft. of Air per Forge

FANS.



PIPE THREADING AND CUTTING MACHINES.



PLANERS (TWO TOOLS 15 TO 20 FT. PER MIN.). RATIO OF CUT TO RETURN 1 : 3.

cuts, each 5/8 inch by 1/8 inch at 60 feet per minute, and at this rate of cutting the machine will require a 60 horse power motor.

Another machine, built for the same class of work and used largely in axle shops and in many railroad shops, is capable of taking two cuts of 3/4 x 1/12 inch, at 24 feet per minute. This requires 18 h.p. and the machine is usually furnished with a 20 h.p. motor. While this power is all right for the full capacity of the machine, 10 h.p. will cover the requirements of the same tool on average railroad shop work.

The number of pits required in a locomotive erecting shop =

$$\frac{\text{(Total number of engines)} \times \text{(average number of days in shop)}}{\text{300 [number of working days in year]}}$$

Example:—400 engines; average days in shop, 25.

$$\text{Number of pits} = \frac{400 \times 25}{300} = 33.$$

$$\text{Capacity per year} = \frac{(\text{Number of pits}) \times 300}{\text{Average number of days in shop.}}$$

In order to reduce to about 20 the average number of days in the shop that are required for general overhauling, it is estimated that the machine shop adjacent to the erecting shop should contain seven machine tools per engine pit, and the floor area in order to accommodate seven tools per engine capacity should be about 1500 square feet per pit.

Power required for air compressors equals the delivery of free air in cubic feet per minute, at 100 lbs. pressure of the compressor, multiplied by 0.14.

Modern erecting and machine shops, including heating, cranes, etc., cost from $2.50 to $3.50 per square foot of inside measurement

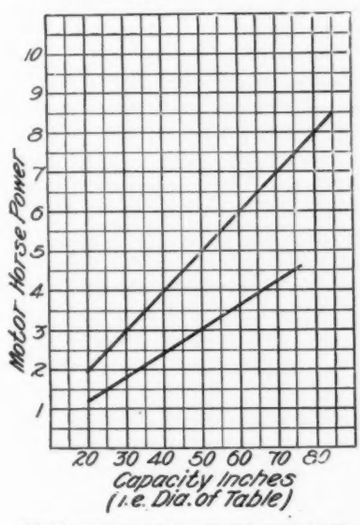
$$\text{Rate per kw. hour to cover fixed charges} = \frac{\text{total fixed charges per year}}{(\text{max. demand}) \times 8760 \times (\text{load factor})}$$

Illustration:

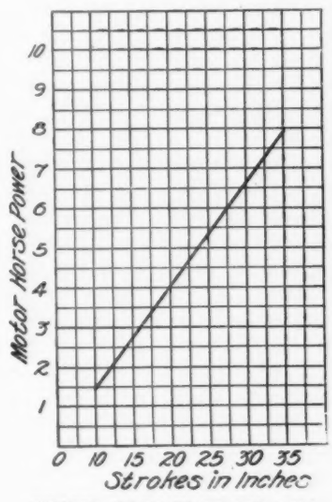
Fixed charges	$8330.00
Maximum demand	500 kw.
Load factor	33 per cent.

Then:

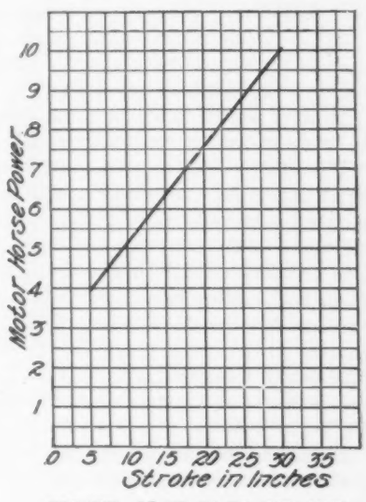
$$\text{rate} = \frac{\$8330}{500 \times 8760 \times .33} = 0.0057$$



DRILL PRESS, 15 TO 20 FT. PER MIN.



SHAPER, 15 TO 20 FT. PER MIN.



SLOTTER, 15 TO 20 FT. PER MIN.

RESULTS OF THE ELECTRIFICATION OF THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD.*

WILLIAM J. WILGUS.

Initial Zone Operation.—As previously stated, the company was forced to confine temporarily the change of motive power to the operation of the suburban zone terminating at High Bridge, 7 miles out; and at Wakefield, 13 miles from the terminal. This postpones for two or three years the extension of electrical service to the northerly termini of the suburban zone. In the meantime, the power on through trains is changed at the temporary termini. At the same points, multiple-unit trains north-bound have steam locomotives attached and thence proceed as non-electric trains; and south-bound the steam locomotives are detached and the trains continue by electricity without locomotives. The average time required for making the changes, including that lost in slowing down and regaining speed is as follows:

Through trains with locomotives	4½ min.
Multiple-unit trains, north-bound	3 "
Multiple-unit trains, south-bound	2½ "

On the Hudson Division this delay has been largely compensated by shortening the line at Marble Hill and the elimination of the grade track crossing at Spuyten Duyvil.

RESULTS.

Expectations from Electrification.—Now that the change of motive power in the initial electric zone has been completed for sufficient time to gain at least a preliminary idea of the results, the question naturally arises, with what success has the change met expectations?

It has already been explained that the principal reasons for undertaking the work were twofold:

(1).—Demand of the public for the abolition of the nuisances incident to the use of steam locomotives south of the Harlem River; and

(2).—Need for increased capacity of the terminal, by the elimination of a large proportion of the switching movements required with steam locomotive practice; and relief to the main line entrance to the terminal by reducing its use for haulage of dead locomotives and cars to Mott Haven.

As secondary considerations there were:

(3).—The possibility of sufficient economy in operation at least to offset largely the additional fixed charges on the cost of the electrical installation; and

(4).—Opportunities for an ultimate large increase in traffic and corresponding growth of revenue to justify the expenditure for all improvements within the suburban zone.

What do the observations made thus far disclose?

The first two expectations have been completely realized.

Park Avenue Tunnel.—The atmospheric conditions in the Park Avenue Tunnel show marked improvement, even with the presence of the remaining New Haven Company's steam service.

Increased Terminal Capacity.—The effect on the operating efficiency of the terminal has been very gratifying, the increased capacity being estimated at one-third. There has also been a large reduction in the number of shop or "dead" trains to and from Mott Haven.

Reduced Cost of Operation.—The results, as regards the third expectation, have been most surprising. The operation, for a considerable period, of steam and electric equipment side by side has afforded an unexampled opportunity for a true comparison of costs of operation. Until now, data on this subject have been based on theory, ignoring many of the indeterminate features of actual operation that have such a weighty effect on costs. For instance, among the variables entering into an analysis of this character are:

(a).—Cost and quantity of coal and water at the power station, and on the steam locomotive tender;

(b).—Relation of ton-mileage of the motive power to total ton-mileage, including motive power and cars;

(c).—Frequency and volume of traffic;

* From a paper on "The Electrification of the Suburban Zone of the New York Central & Hudson River Railroad in the Vicinity of New York City," presented at the March 18, 1908, meeting of the American Society of Civil Engineers, see page 68, Number 2, Volume XXXIV, of the *Proceedings*. The paper is very extensive and complete. It considers the reasons for the electrification of the New York Central; also the reasons for the adaption of direct-current and other important features. It discusses at length the general features of construction and equipment and closes with the section on "Results."

TABLE 1.—Comparison of Costs per Day of Available Service of Steam and Electric Locomotives for Interest, Depreciation, Repairs, Inspection, and Handling.

Subject.	Steam.			Electric.		
	Description.	Amount per annum.	Per day.	Description.	Amount per annum.	Per day.
Interest	4½% on $15 000	$637.50		4½% on $30 000	$1 275	
Depreciation	5% on $15 000	750.00		5% on $30 000	1 500	
Repairs	General at West Albany	$1 170		General at Harmon	$468	
	Running at Mott Haven	414		Running at High Bridge and Wakefield	166	
	Trips to shops, 300 miles	168		Trips to shops, 60 miles	34	
	Use of shops	90	1 842.00	Use of shops	36	704
	Total for 335 days available for service.		$3 229.50	$9.64	Total for 350 days available for service.	$3 479	$9.94
Handling and inspection, including fixed charges and maintenance of land and structures	Mott Haven engine-house plant, 365 days		1 231.00	3.37	High Bridge and Wakefield inspection sheds, 365 days	200	0.55
Total			$4 460.50	$13.01		$3 679	$10.49

The saving in favor of the electric locomotive, therefore, is $2.52 per day, equal to 19 per cent.

(d).—Mechanical and electrical design of motive power as affecting repairs, and hours available for active service;

(e).—Fixed charges, depreciation, and maintenance on all items of both kinds of service, that have a bearing on comparative results, including land, structures, and equipment.

In other words, to obtain a true comparison, observations must be made under like conditions in a known service.

With this object in view, a typical steam switching locomotive,* engaged in terminal service, and a steam passenger locomotive,† assigned to road service, were each selected for observation in the same class of traffic with electric locomotives.‡ The terminal service embraced switching at the Grand Central yard, and hauling dead cars to and from Mott Haven storage yard, a distance of 6 miles. The road service comprised the hauling of schedule trains by the electric locomotive between the Grand Central Terminal and Wakefield, 12½ miles; and the same trains by steam between Wakefield and North White Plains, 11½ miles.

Observers constantly rode the locomotives for the period of the tests, namely, September 12th to 27th, 1907, in terminal service, and October 4th to 18th, 1907, in road service. Cyclometers and wattmeters registered actual distances, speeds, and current consumption. Record was also kept of the number of cars switched and hauled, and the proportion of time each day engaged in actual service, awaiting duty, and laid up for inspection and repairs.

The coal used contained 14,000 B. T. U. per lb., and the cost, per ton of 2,240 lb., was:

Steam locomotive in terminal service (anthracite)	$5.00 per ton.
Steam locomotive in road service (bituminous)	3.50 " "
Port Morris power station (bituminous)	3.05 " "
Water, per 1,000 gal., cost as follows:	
Terminal service and at power station	13 1/3 cents
Road service	5 "

The cost of electric current, when the power station designed load is attained, is taken at 2.6 cents per kw.-hr., delivered at the contact shoes of the equipment, and includes all operating and maintenance costs, interest on the electrical investment required to produce and deliver the current, depreciation, taxes, insurance, and transmission losses. The details of this cost are:

Items.	Operating costs.	Fixed charges.	Total.
Power station	$0.58	$0.44	$1.02
Transmission losses	0.19	0.15	0.34
Distributing system and sub-stations	0.32	0.92	1.24
Totals	$1.09	$1.51	$2.60

Locomotive wages are practically identical for each class of service.

* Six wheel; wheel base 11 ft. 6 in.; weight on drivers, working order, 152,500 lbs.; weight of 4,500 gal. tender, 89,500 lbs.; weight of 5,100 gal. tender, 91,500 lbs.

† Ten wheel; rigid wheel base 15 ft. 10 in.; wheel base of engine, 26 ft. 10½ in.; weight on drivers, working order, 156,000 lbs.; weight on truck, 46,500 lbs.; weight of tender loaded, 148,000 lbs.

‡ See American Engineer, Jan., 1907, page 1. Rigid wheel base, 13 ft.; total wheel base, 27 ft.; total weight, 189,000 lbs.; weight on drivers, 137,000 lbs.; normal capacity of each locomotive, 2,200 h. p.; overload capacity, 3,300 h. p.

Table 1 shows the details of locomotive repairs, maintenance, and fixed charges for each class of service, from which it will be noted that, although the fixed charges and depreciation of the electric locomotive are higher than those of the steam, owing to the greater first cost, the net result is in favor of the electric locomotive, due to lower costs for repairs and maintenance. These results are based on actual observations of the steam locomotive covering a period of several years; and of the electric locomotive for two years on the experimental track near Schenectady and one year in the New York zone. The reasons for the lower cost of repairs on the electric machine are the simplicity of construction and the minimum number of mechanical parts. It is also worthy of comment that the electric locomotive costs very much less per day for repairs and maintenance, due to lower expenses for land and structures and fewer days out of service. For instance, the fixed charges and cost of maintenance and operation of the extensive steam engine plant on costly land, are comparable with the simple inspection-shed charges of the electric locomotive. The Schenectady experiments indicated that the cost of repairs of the electric locomotive of this type is about two-fifths of that of the steam locomotive of a corresponding age and capacity.

The results of these observations are summarized in Table 3. They show that, under the stated conditions, the electric locomotive has the following advantages over its steam rival:

19% saving in locomotive repairs and fixed charges.
18% saving in dead time for repairs and inspection.
25% greater daily ton-mileage.
6% saving in locomotive ton-mileage in hauling service.
11% saving in locomotive ton-mileage in switching service.
16% saving in locomotive ton-mileage in road service.
12% net saving in cost in hauling service.
21% net saving in cost in switching service.
27% net saving in cost in road service.

Even better results may be expected during winter months, when steam locomotives are subjected to many conditions that cause additional expenses not incident to the electric locomotive.

Reduced Cost of Grand Central Terminal Operation.—Owing to the partial use of steam switching locomotives, and the presence of the New Haven Company's steam road locomotives at the terminal, the full benefits of change of motive power have not yet been secured. However, on the same wage basis for 1907 as for 1906, the month of August, 1907, showed a decrease in cost of terminal locomotive and yard operation of nearly $3,000, although the number of cars in and out increased from 64,984 to 68,519. In other words, the cost of operation decreased 9 per cent. while the work done increased 5½ per cent., which is equivalent to a net saving of 13½ per cent.

Increased Revenue.—As to the fourth expectation—increased revenue from a larger volume of business—no definite conclusions can be reached until the extension of electrical service and the completion of the various other improvements afford an opportunity for increase in frequency and speed of train service; for the production of revenue from various sources at the terminal; and for the expansion of business that is sure to follow

TABLE 3.—SUMMARY OF COMPARATIVE TESTS OF STEAM AND ELECTRIC LOCOMOTIVES.

Kind of locomotive.	Miles per day.	Cars per day.	Busy hours per day.	Hours ready for duty daily.	Percentage of time dead.	Total ton-miles daily.	Car ton-miles daily.	Percentage of car ton-miles to total.	Car ton-miles per busy hour.	Coal or current per car ton-mile.	Total cost per car, in cents.	Speed and stops. Average miles per hour.	Speed and stops. Maximum miles per hour.	Speed and stops. Stops.	Cost per 1 000 car ton-miles. Supplies.	Wages.	Interest, depreciation, and repairs on locomotives.	Total.	Watt-hours required to do work of 1 lb. coal.
SWITCHING SERVICE—GRAND CENTRAL TERMINAL.†																			
Steam	10.91	55	†1.83	†6.16	†0.52	2 580	916	0.35	501	3.36 lb. coal.	35.2	....	....	....	$8.06	$5.34	$7.61	$21.01	79
Electric	11.13	53	†2.01	†6.80	†0.26	1 980	914	0 46	445	264 watt-hr.	28.5	....	....	....	6.88	5.25	4.40	16.53	
Advantages in favor of electric locomotives	0.22	....	†0.18	†0.64	†0.26	.....	.....	0.11	....	.....	6 7	....	....	....	1.18	0.09	3.21	4.48	
HAULING TO AND FROM MOTT HAVEN.†																			
Steam	40.0	45	†3.36	†5 18	†0 53	16 540	11 720	0.71	3 490	0.46 lb. coal	51.6	11 9	48	0.9	1.12	0.35	0 52	1.99	96
Electric	78.4	95	†6.41	†10.42	†0.30	30 370	23 310	0 77	3 640	44.3 watt-hr.	43.2	12.3	45	2.0	1.16	0.31	0.28	1.75	
Advantages in favor of electric locomotives.	38.4	50	†3.05	†5.24	†0.23	13 830	11 590	0.06	150	....	8.4	0.4	3	1.1	.....	.....	0.24	0.24	
ROAD SERVICE.*																			
Steam	74.04	28	3.72	‡11.11	‡0.54	25 620	12 660	0 49	3 400	1.22 lb. coal	126.0	19.9	60	8.6	2 03	0 28	0.46	2.77	48
Electric	126.22	43	5.34	‡13.70	‡0.43	33 210	21 510	0 65	4 030	52.3 watt hr.	100.0	23 6	55	2.9	1 37	0.31	0 34	2.02	
Advantages in favor of electric locomotives.	52.18	15	1.62	‡2.59	‡0 09	7 590	8 850	0.16	630	....	26.0	3.7	5	....	0.66	....	0 12	0.75	

* Portion of time of locomotives engaged in other service not shown in this table † Switching and hauling done by same locomotives.
‡ Total time of locomotives in all classes of service.

the enlargement of the facilities of the company throughout the suburban zone, not only as regards the local service, but in an even larger degree from long-haul freight and passenger traffic.

Summary of Results.—To summarize, the observations thus far made demonstrate that this pioneer electric installation in heavy-traction trunk-line work in the United States has fully accomplished the purposes that prompted its adoption, namely:

(1).—Abolition of nuisances incident to the steam locomotive; and

(2).—Increased capacity of the Grand Central Terminal, a full year in advance of the date fixed by law; and in addition:

(3).—The promise, with the completion of the changes, of a saving, in cost of operation, of from 12 to 27 per cent., after providing for increased capital charges for electrification; and

(4).—The outlook of a large future growth of remunerative traffic, and other sources of revenue attendant on the use of electricity, much more than sufficient to provide for the increased capital charges for the other improvements.

Several years will be consumed in the gradual rounding out of the work as a whole; but it is gratifying to have this early indication of the success of the undertaking from both the engineering and financial standpoints.

Other Operating Conclusions.—Apart from these results, it is interesting to note the conclusions, suited to this particular problem, that may be drawn from a study of the various observations.

Equipment designed for the electric system over which it is to operate offers economies so superior as to overshadow any other advantages that may be claimed for a kind of equipment that can be operated over several systems.

In switching service, the economy of electric traction lies in savings for supplies, and in lower unit fixed charges and repairs due to less lost time for repairs and care.

In slow-speed hauling, the advantage lies in the lower unit fixed charges and repairs of the electric locomotive, due to its ability to do more work while busy, and to less lost time for repairs and care.

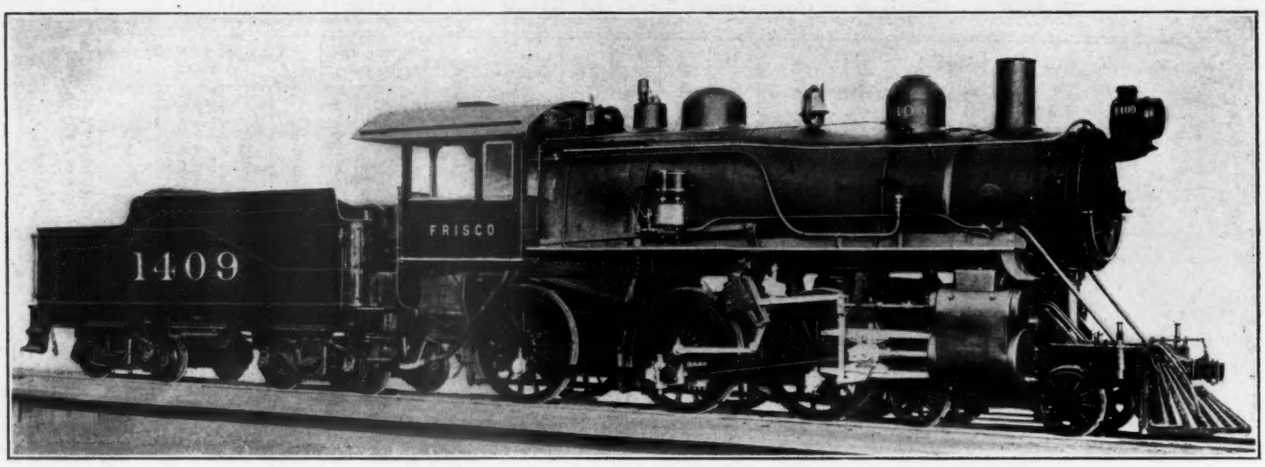
High-speed road service shows advantages for electric traction in all three items: supplies, wages, and fixed charges and repairs. The small 18 per cent. increase in current consumption for the greater speed of road service, as compared with hauling service, is in marked contrast to the 165 per cent. increase in coal consumption for steam traction.

Opportunities for large economies lie in the thorough training of motormen in the manipulation of their controllers, a very simple problem as compared with the difficulties of teaching both the enginemen and firemen on steam locomotives to perform their duties so as to result in fuel economy.

Maintenance of Track and Structures.—It is yet too early to express in dollars the comparative effect of steam and electric traction on the cost of maintaining and renewing tracks and structures. Repeated systematic inquiries of all foremen in charge of electric zone track maintenance, and of the motormen operating electrical equipment, have brought out the practically unanimous opinion that the effect of electric locomotives, apart from slightly greater wear on switches, does not differ from steam motive power, on either line or surface of tracks, but that the former has better riding qualities. The superiority of electric traction is manifest, of course, in the cessation of costly corrosive action of locomotive gas on metallic structures, and the freedom from cinders which, with the steam locomotive, cause heavy maintenance costs for cleaning, rock ballast, and pointing brick tunnel arches.

CONSERVATION OF THE NATION'S FUEL SUPPLY.—At a meeting held Tuesday, April 14, under the auspices of the American Society of Mechanical Engineers, Dr. W. F. M. Goss, Dean of the College of Engineering, University of Illinois, spoke upon the conservation of the nation's fuel supply, saying that economy in its production and use is to be enforced by a four-fold process. The necessary steps are: Scientific research for the establishment of facts; practical demonstrations of facts thus developed on a scale which will convince men that there is profit, direct or indirect, in a better practice; restrictive legislation which will protect the public from the competition of unscrupulous men; and finally effective inspection which will secure an enforcement of law. The process cannot successfully begin with coercion; it must begin with education.

SAFETY DEVICES EXPOSITION.—The second international exposition of safety devices was opened on April 13, at 231 W. 39th street, New York, and will continue until June 1.



TEN-WHEEL PASSENGER LOCOMOTIVE—ST. LOUIS & SAN FRANCISCO RAILROAD.

TEN WHEEL PASSENGER LOCOMOTIVE.

ST. LOUIS & SAN FRANCISCO RAILROAD.

The Baldwin Locomotive Works has recently delivered to the St. Louis & San Francisco Railroad ten passenger locomotives of the ten-wheel type, which are among the heaviest engines of this class ever built by that company.

About a year ago there appeared in these columns (Page 104, 1907), a description of some locomotives of the same type for passenger service, built for this railroad by the American Locomotive Company, which weighed 183,000 lbs. total and had 21 x 26 in. cylinders. They were equipped with Walschaert valve gear and an extended wagon top type of boiler, having a total heating surface of 2,654 sq. ft. The locomotives in this later order are considerably larger and more powerful and exceed the earlier ones in every dimension except grate area. The boiler is 68 in. diameter at the front ring as compared with 66⅜ in.; there are 364 2-in. tubes in place of 318; the cylinders are 23 x 26 in.; the weight has been increased to 194,450 lbs., of which 141,050 is on drivers, and the tractive effort delivered with the same steam pressure is 33,900 instead of 28,300. A comparison of the ratios between these two designs will show that the increased power is based on the increased amount of heating surface backed up with probably a somewhat higher rate of combustion on the grates.

The accompanying table will permit an easy comparison of this design with several other recent engines of this type and indicates that this power, while primarily designed for passenger service, will also be found to be very satisfactory for fast freight service.

Road	S. P.	T. & P.	Frisco.	N. Y. C.	C.&N.W.
Total weight	203,050	197,000	194,450	194,500	179,500
Weight drivers	159,750	165,000	141,050	148,000	135,500
Tractive effort	34,740	38,400	33,900	31,000	30,900
Wgt. driv. ÷ total wgt. %	78.5	83.5	72.5	76.	75.3
Wgt. per driving axle	53,250	55,000	47,017	49,333	45,167
Cylinders	22 × 28	22 × 28	23 × 26	22 × 26	21 × 26
Diam. drivers	63	63	69	69	63
Steam pressure	190	210	200	200	200
Total heating surface	2,994	2,931	3,089	3,327	2,959
Tube heating surface	2,788	2,731	2,867	3,124	2,808
Total heat. surf. ÷ vol. cyl.	243	236	243	292	285
B. D. ratio	730	825	770	642	655
Reference in AMER. ENG.	p. 480-07	p. 77-08	.....	p. 59-06	p. 247-07

The most interesting feature of this design is found in the arrangement of the Walschaert valve gear, which, as do all the later designs, shows much improvement over the earlier arrangements. The most striking feature is the placing of the combination lever behind the guide yoke with the union link extending back from the cross head, and the employment of a very long valve stem, having a guide and bearing bolted to the guide yoke. This shortens up the radius bar considerably and permits the locating of the link somewhat further back than has been the previous custom with ten-wheel engines. This location in turn reduces the size and weight of the link support, which is fastened to the frame cross tie. It also compels the use of a short eccentric rod, the errors of angularity being largely overcome in this case by a long extension on the link. The reverse shaft bearing and link bearing are both incorporated in one casting bolted to the frame cross tie, the simplicity and lightness of which are shown in the detail illustration. This arrangement of the gear permits the use of the simpler design of guide yoke and allows it to be located much nearer the back ends of the guides.

The relief valve, noticed on top of the valve chest, consists simply of a plate resting on top of a horizontal seat and normally covering openings leading to the live steam ports. When the throttle is opened this plate is held down by boiler pressure acting on its upper surface. Excessive pressure within the cylinders, which acts upon a smaller area than the boiler pressure above, lifts this plate from its seat and opens communication between the two live steam ports.

The general dimensions, weights and ratios of these locomotives are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	33,900 lbs.
Weight in working order	194,450 lbs.
Weight on drivers	141,050 lbs.
Weight on leading truck	53,400 lbs.
Weight of engine and tender in working order	315,000 lbs.
Wheel base, driving	15 ft. 10 in.
Wheel base, total	26 ft. 10 in.
Wheel base, engine and tender	57 ft. 10 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.16
Total weight ÷ tractive effort	5.72
Tractive effort x diam. drivers ÷ heating surface	770.00
Total heating surface ÷ grate area	64.00
Firebox heating surface ÷ total heating surface, per cent	5.65
Weight on drivers ÷ total heating surface	46.50
Total weight ÷ total heating surface	63.50
Volume both cylinders, cu. ft.	12.50
Total heating surface ÷ vol. cylinders	243.00
Grate area ÷ vol. cylinders	3.79

CYLINDERS.

Kind	Simple
Diameter and stroke	23 x 26 in.

VALVES.

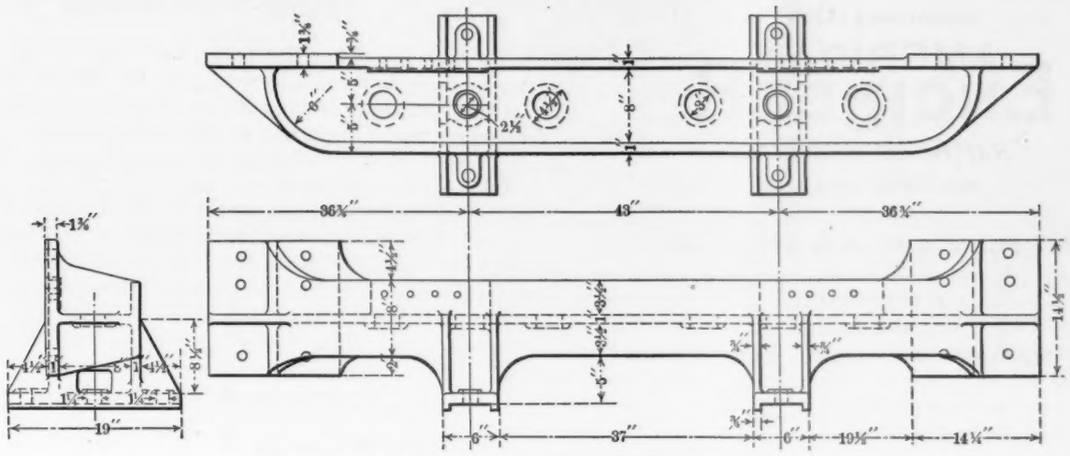
Kind	Piston
Diameter	13 in.
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	⅛ in.
Lead, constant	¼ in.

WHEELS.

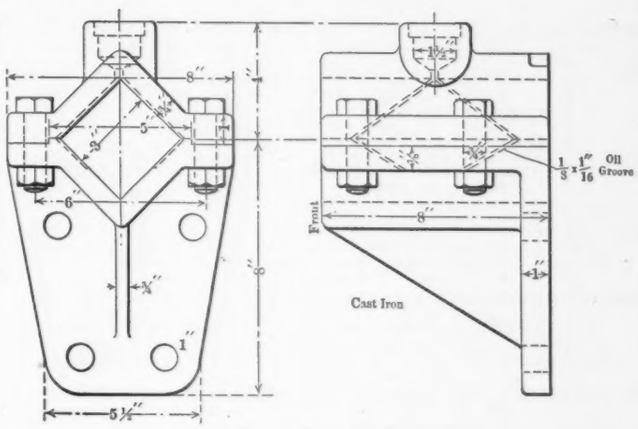
Driving, diameter over tires	69 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10 x 12 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck journals	6½ x 10 in.

BOILER.

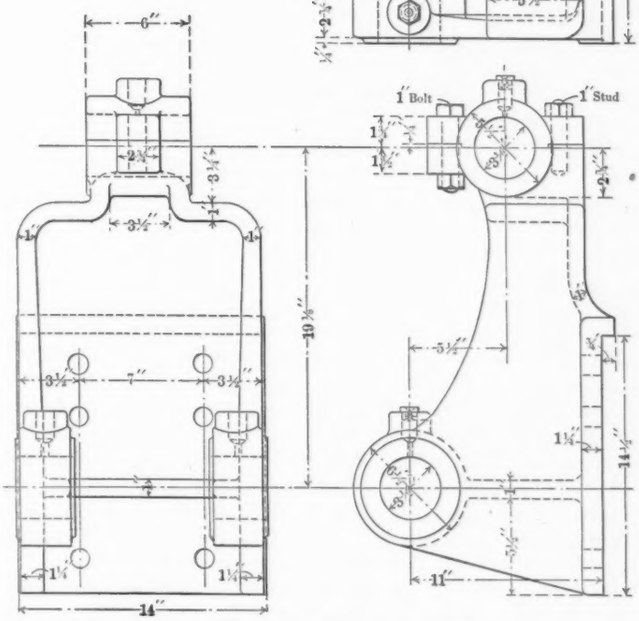
Style	E. W. T.
Working pressure	200 lbs.
Outside diameter of first ring	68 in.
Firebox, length and width	101¾ x 67¼ in.
Firebox plates, thickness	3/8 & 1/2 in.
Firebox, water space	F-4, S. & B-3½ in.



FRAME CROSS TIE SUPPORTING LINK AND REVERSE SHAFT BEARINGS.



VALVE STEM BEARING ON GUIDE YOKE.



LINK AND REVERSE SHAFT BEARINGS.

Tubes, number and outside diameter	364—2 in.
Tubes, length	15 ft. 1¼ in.
Heating surface, tubes	2,867 sq. ft.
Heating surface, firebox	172 sq. ft.
Heating surface, total	3,039 sq. ft.
Grate area	47.7 sq. ft.
Smokestack, height above rail	15 ft. 8½ in.
Center of boiler above rail	9 ft. 8 in.

TENDER.

Tank	Water Bottom
Frame	Steel
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	6,000 gals.
Coal capacity	12 tons.

PRODUCER GAS ENGINE PLANT FOR RAILWAY REPAIR SHOP.—Among the first railway repair shops in which the suction producer and gas engine have been introduced is the main car repair shop of the Minneapolis & St. Louis Railroad at Minneapolis. This shop being in the vicinity of a fashionable residence district, it was desirable to suppress the smoke nuisance, and in making the necessary improvements in the power plant it was decided to use gas engines. The elimination of smoke has been effected and it is reported that in operation the plant shows a low cost for fuel. The coal used is anthracite pea and the consumption, when the engines are carrying 75 to 80 per cent. of normal rate, is only one pound per brake horsepower, and the total cost of fuel, attendance and operation is given as $1.24 per horsepower per month. There is one engine of 140 horsepower for the mill and two engines of 80 horsepower for driving electric generators. The first cost of large gas engine plants is virtually on a par with first-class reciprocating engine plants, about $100 per horsepower, while the costs for fuel, for labor, handling of coal and ashes, and for maintenance, are each reported to be about one-half as much per unit as the corresponding items for a plant using steam engines and boilers.—*Railway Age.*

COST OF WATCHING THE RAILROADS.—A communication from the Interstate Commerce Commission transmitted to the house of representatives states that it will cost the United States government $750,000 a year for the supervision of railroad accounts under the present Interstate Commerce act. The document contains a letter from Commissioner Harlan, in which he says that it will require a board of examiners, composed of 285 men, especially trained in the methods of railway accounting, to supervise the accounts and practices of the steam railroads. This estimate does not cover such examiners as may be required later to supervise the accounting methods of express companies, water lines and pipe lines.—*Railway and Engineering Review.*

On Wednesday, March 18, the last open space in the Blackwell's Island Bridge, in New York City, was connected and the headings of the last of the four Pennsylvania Railroad tunnels under the East River were joined.